Climate Forecasting Unit

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

RPI2.0 Connecting Science and (Re)Insurance

Forecast Skill Assessment of 5-year mean North Atlantic Sea Surface Temperature (and implication for hurricanes)

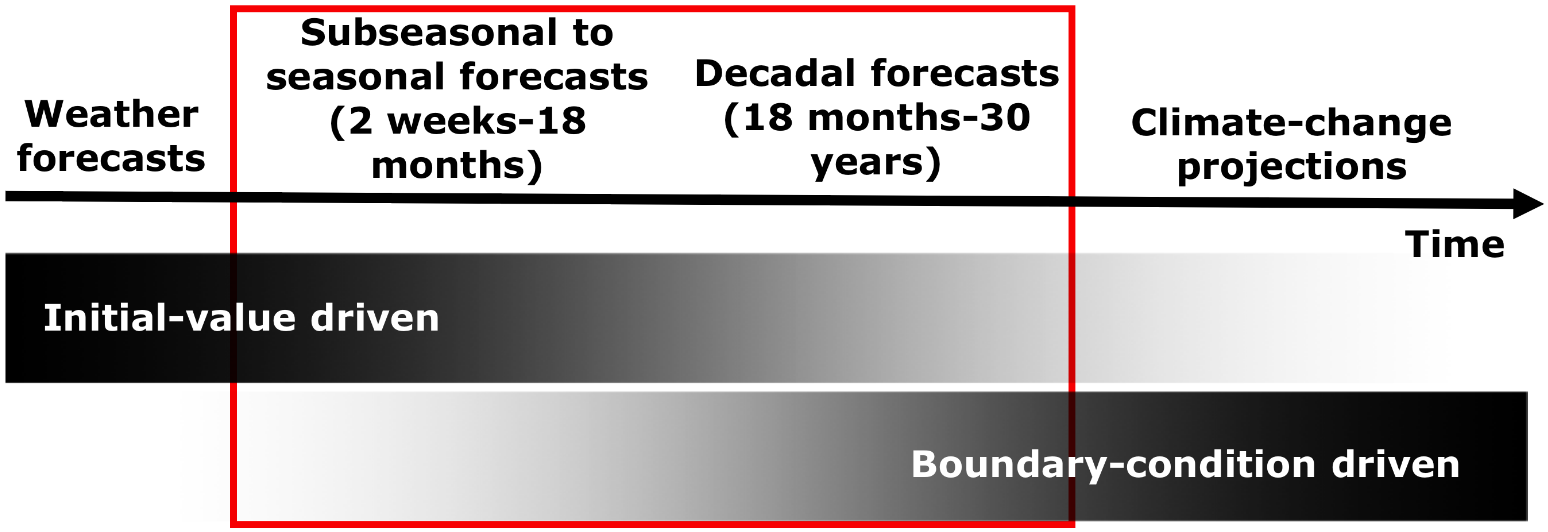
Louis-Philippe Caron

Climate Forecasting Unit, IC3, Barcelona

RPI2.0 Workshop on Atlantic Hurricane Volatility,
June 17th, 2015

Climate prediction

Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.



Adapted from Meehl et al. (2009)

- observed initial conditions
Atm - Ocn – Ice

-greenhouse gases (GHG)

- volcanic aerosols

- SO_4

- solar activity

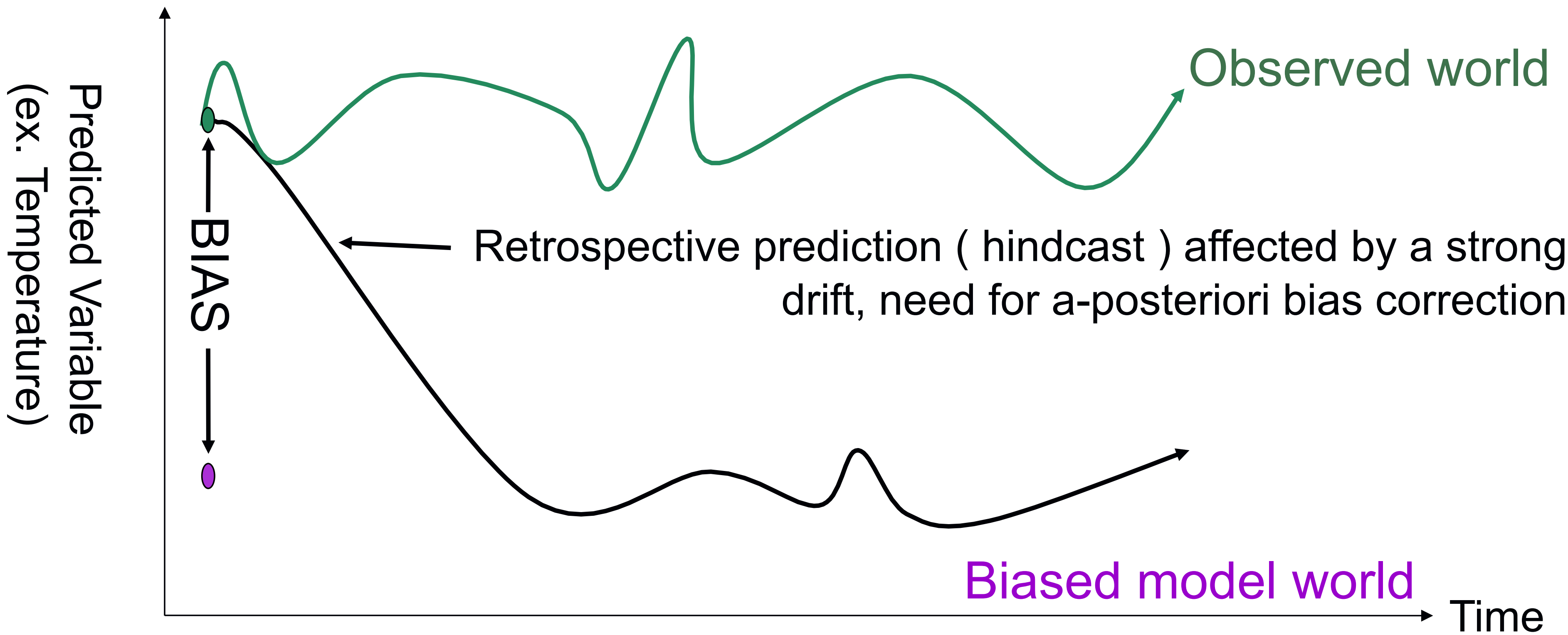
initialized runs

Near-term climate predictions make use of information related to anthropogenic climate change, natural forcings and natural variability.

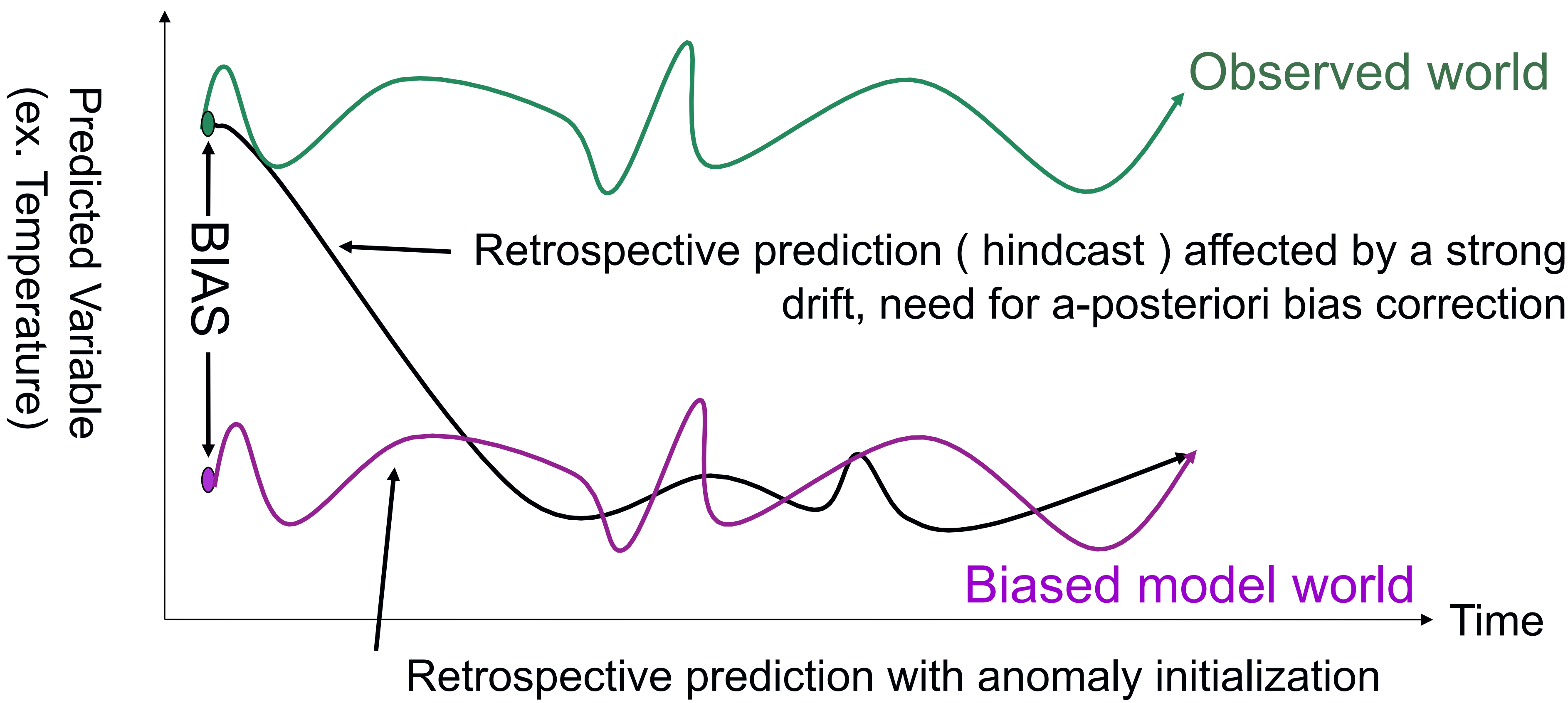
non-initialized runs

(CMIP5 historical)

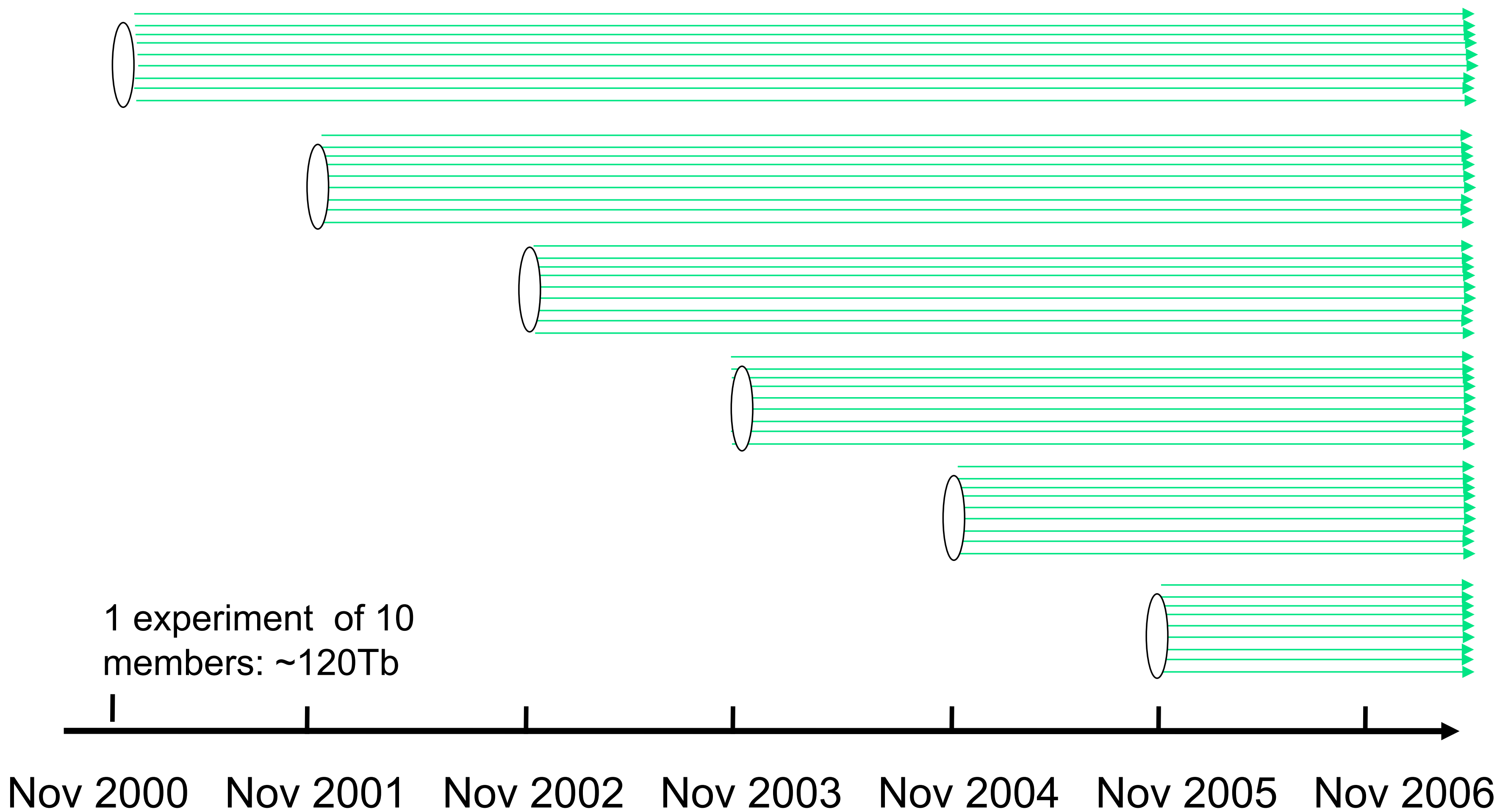
The climate prediction drift issue



The climate prediction drift issue

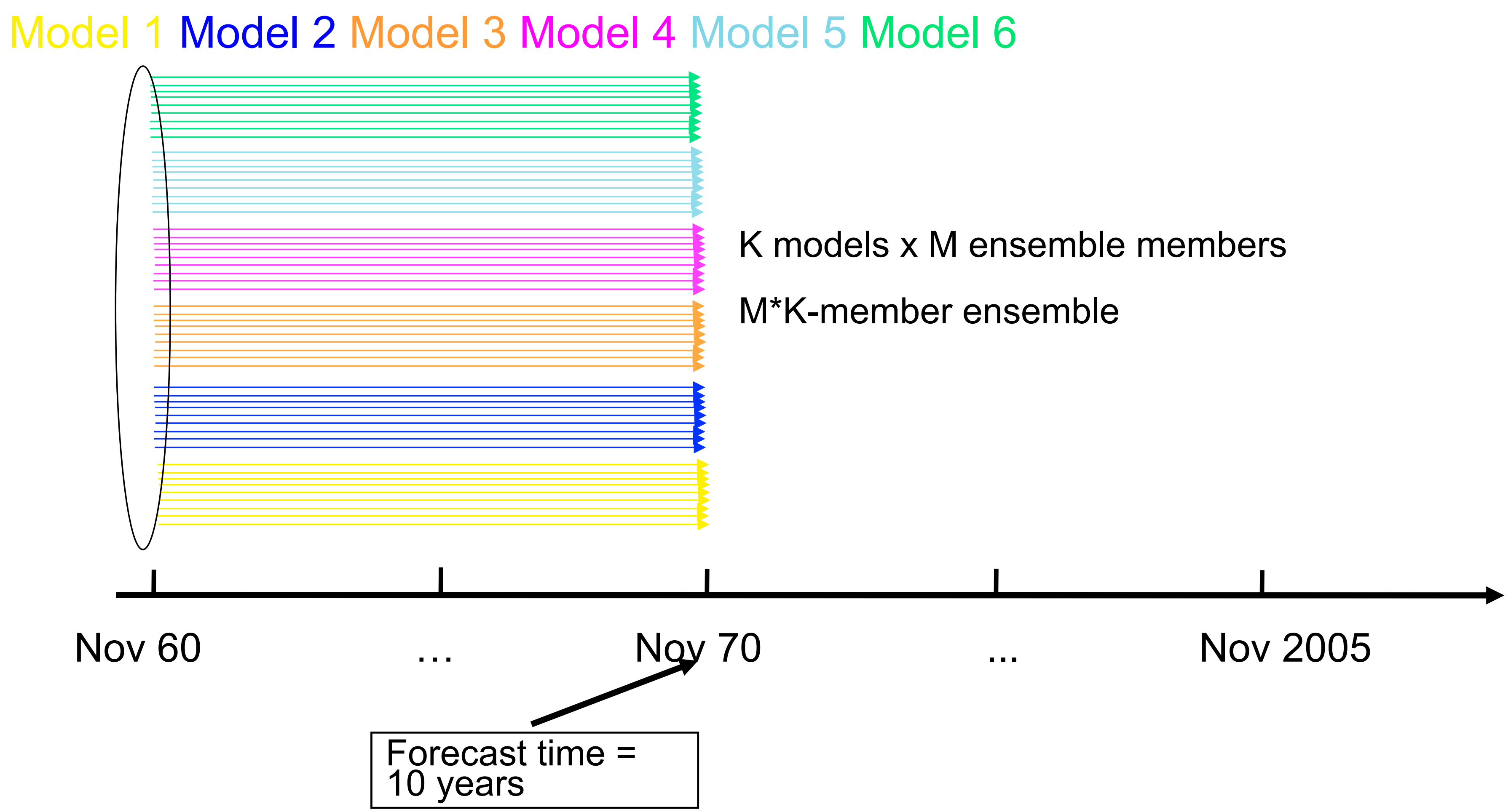


Ensemble initialized near-term predictions

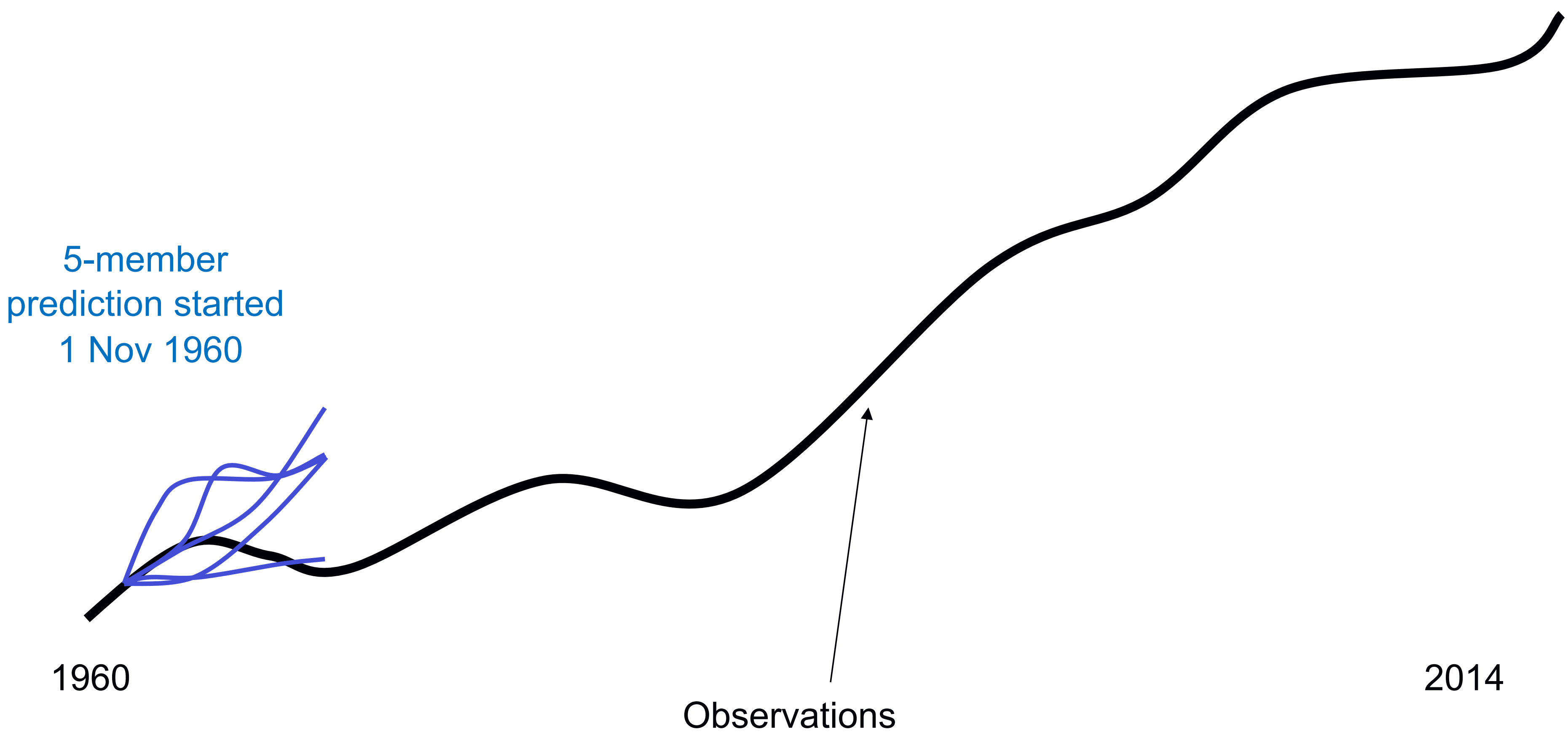


Ensemble climate forecast systems

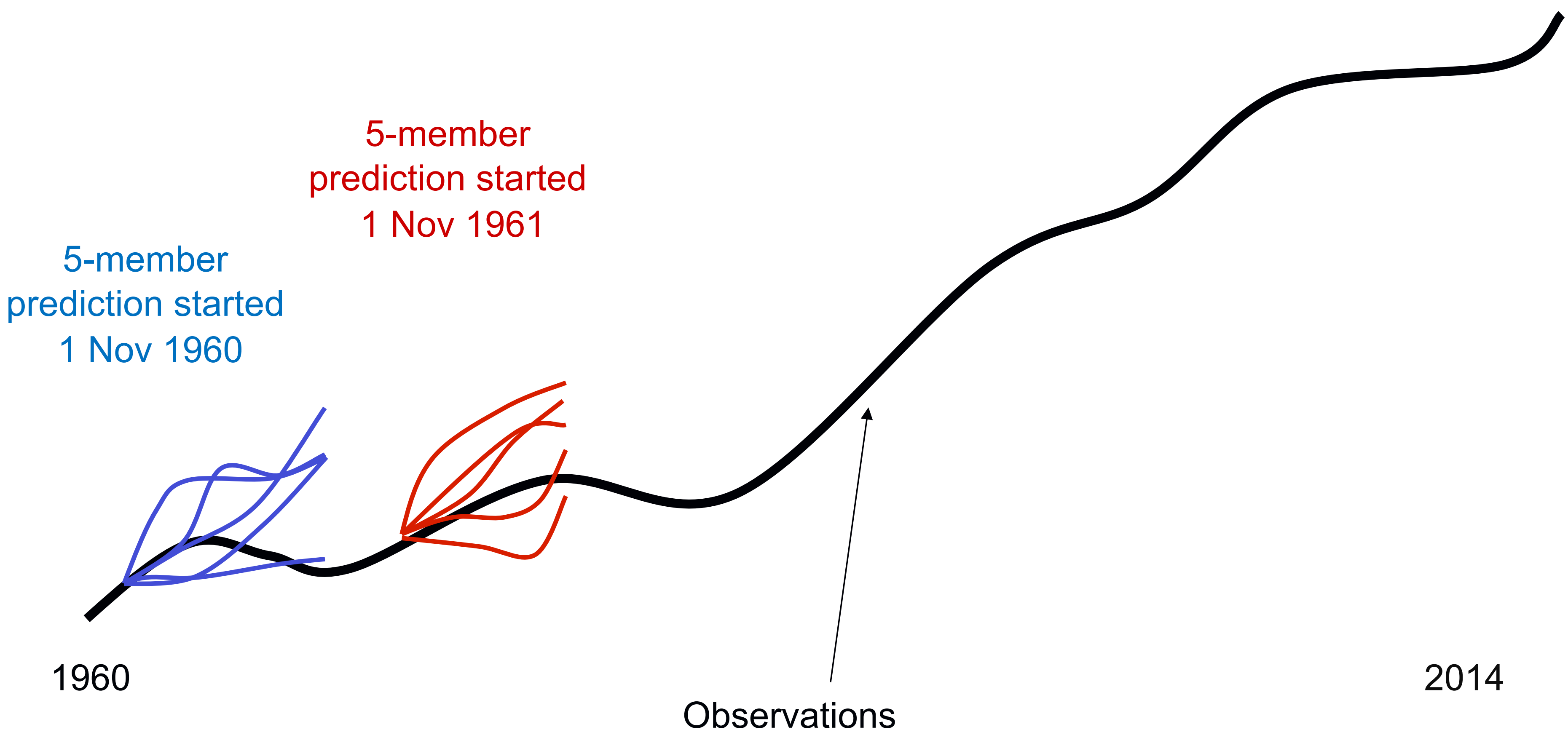
Assume a multi-model ensemble system with coupled initialized GCMs



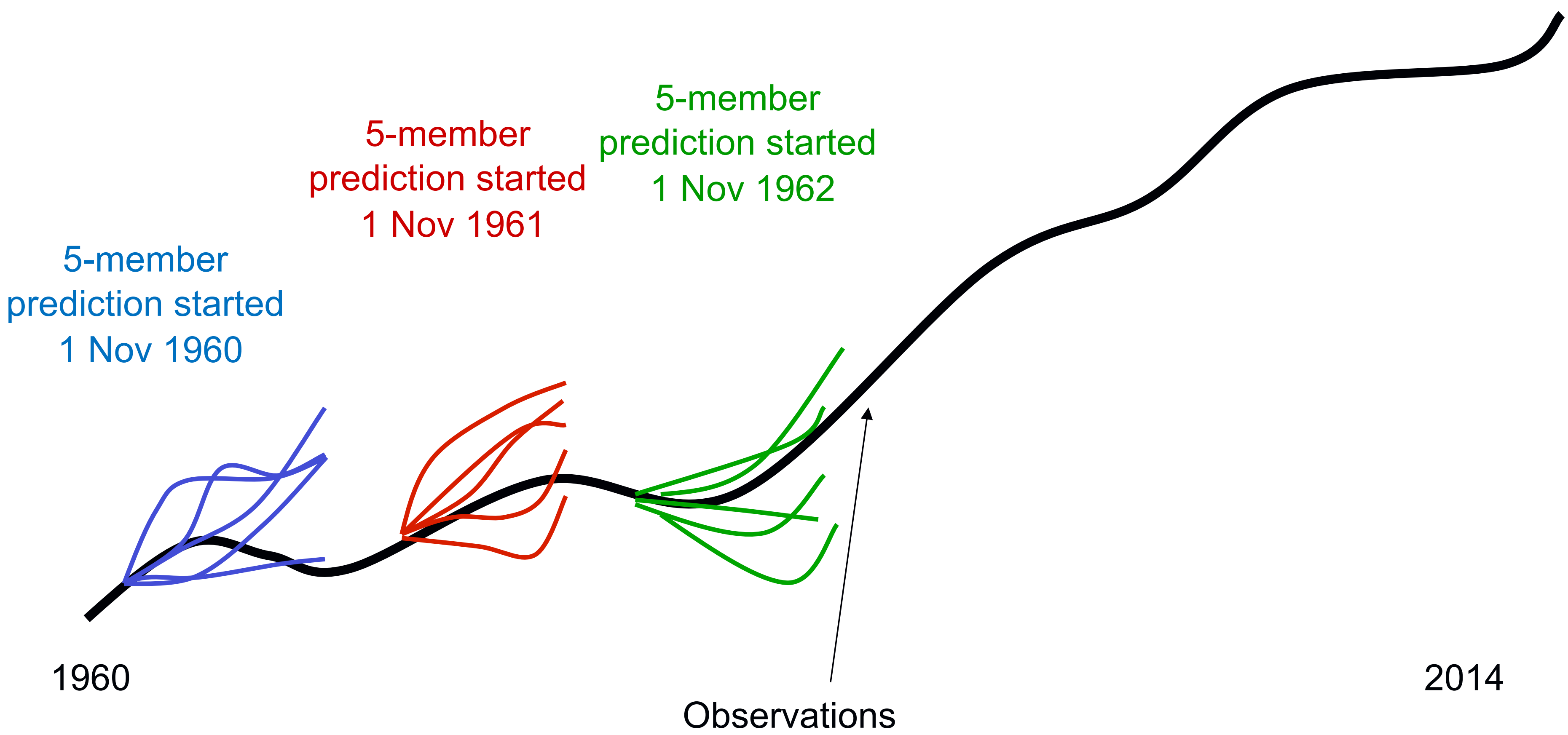
Experimental setup : 1 grid-point



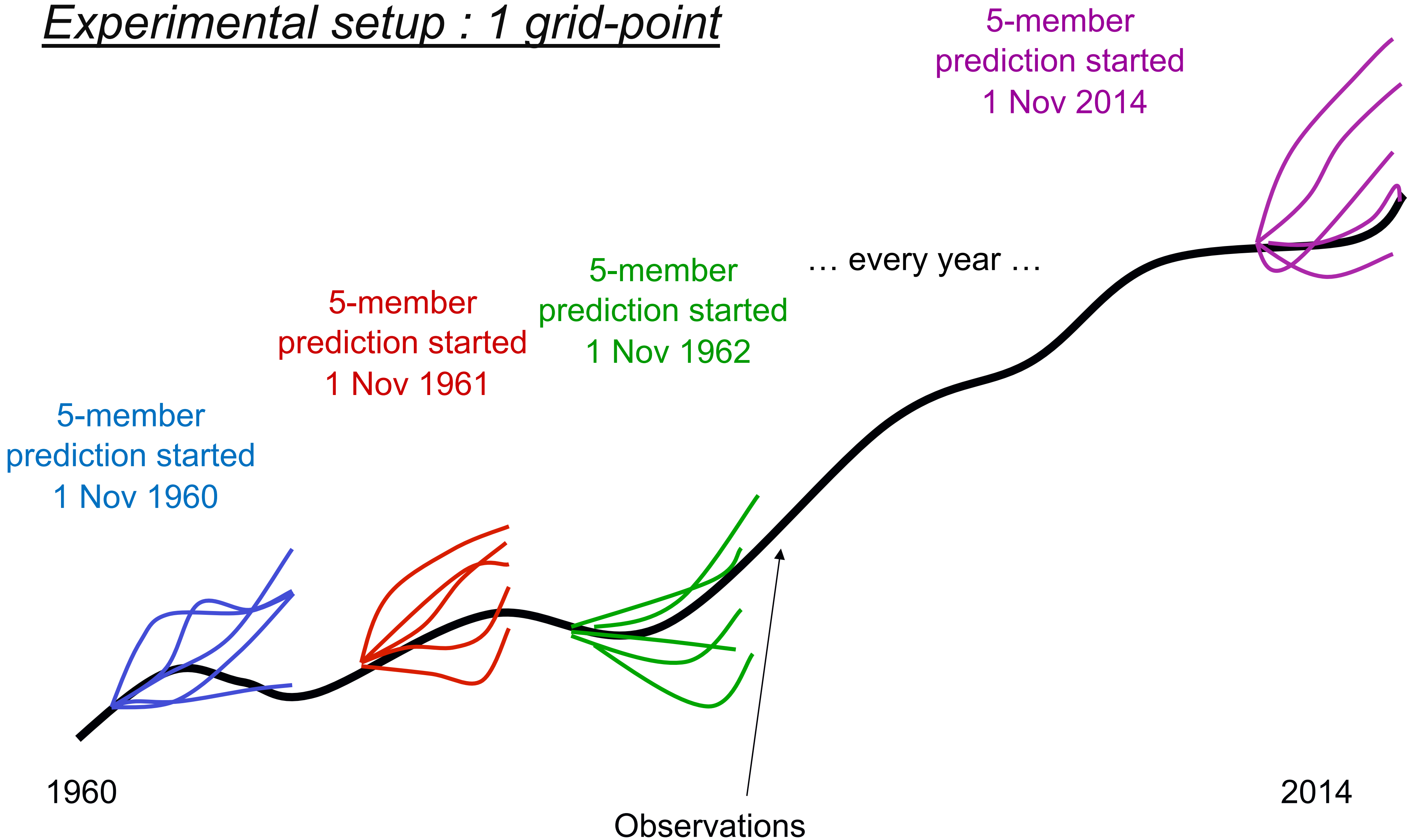
Experimental setup : 1 grid-point



Experimental setup : 1 grid-point



Experimental setup : 1 grid-point



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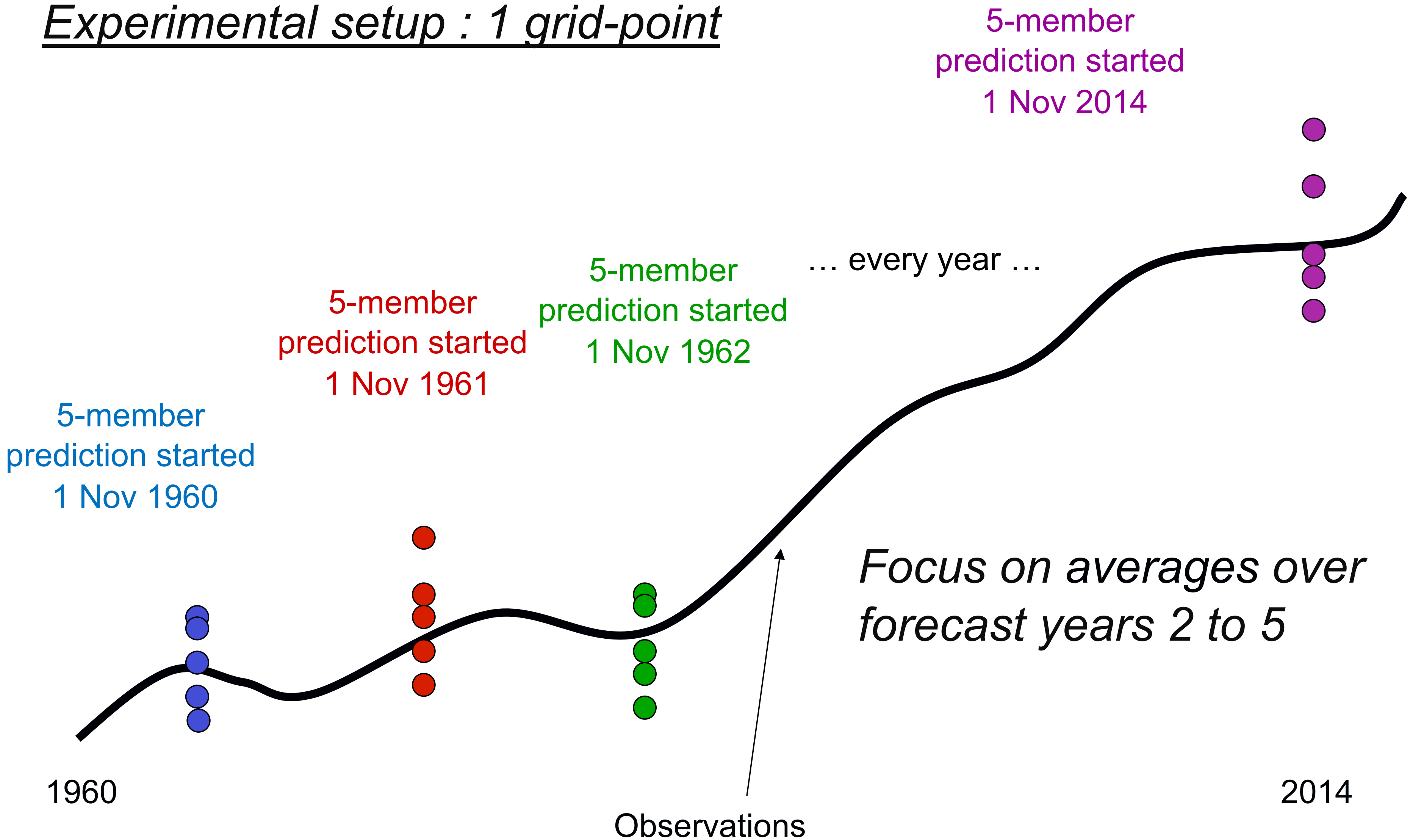
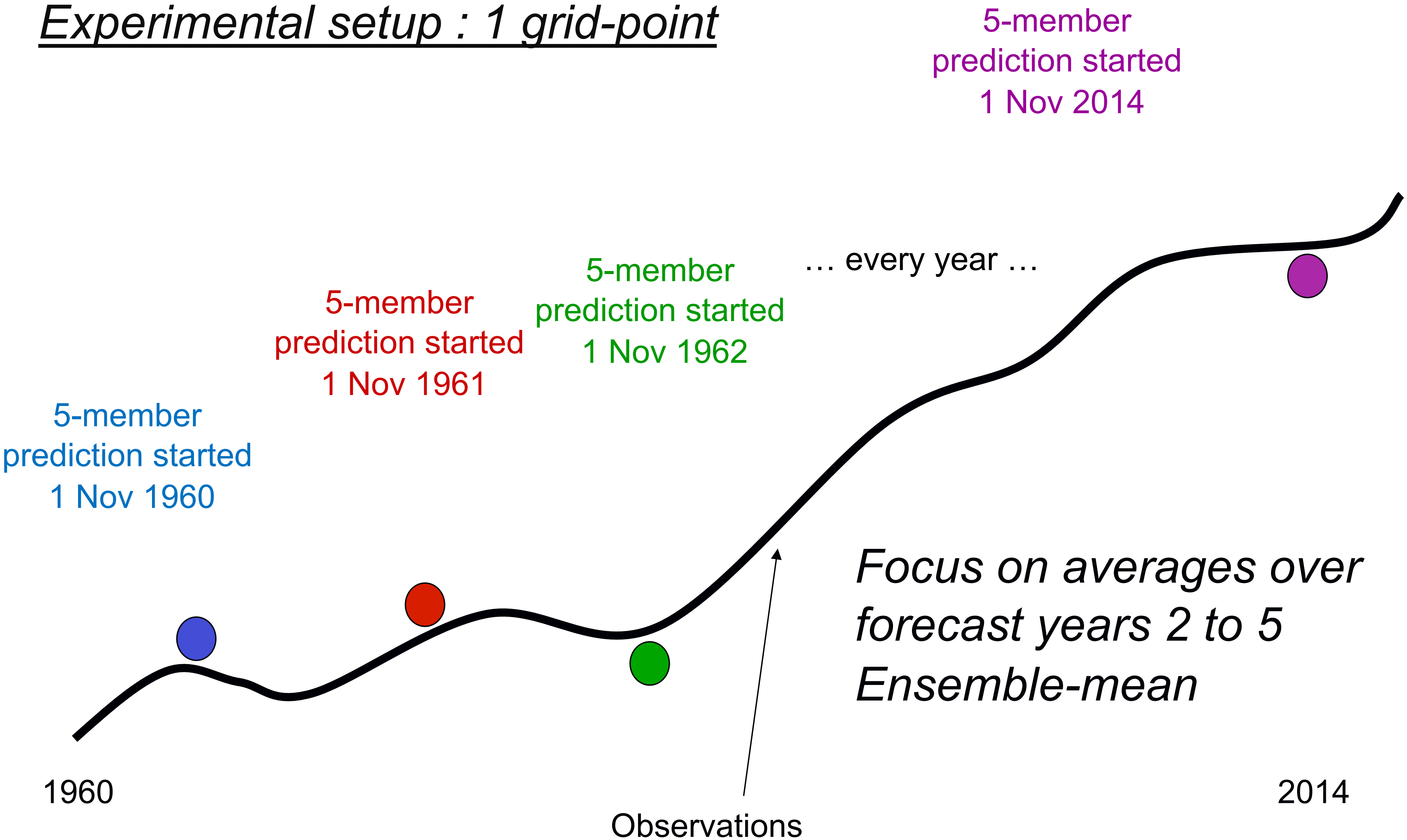


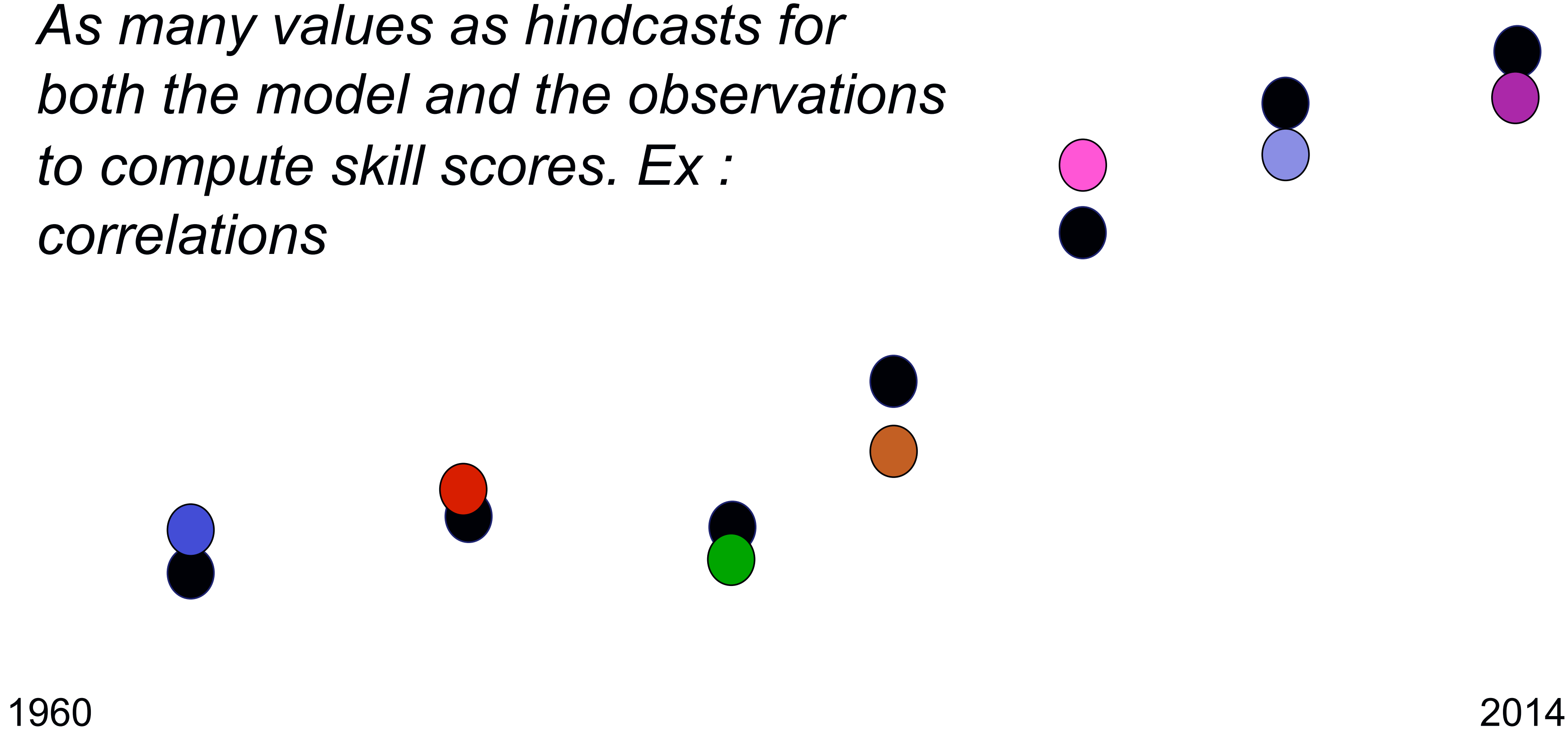
Experimental setup : 1 grid-point



Focus on averages over forecast years 2 to 5
Ensemble-mean

Experimental setup : 1 grid-point

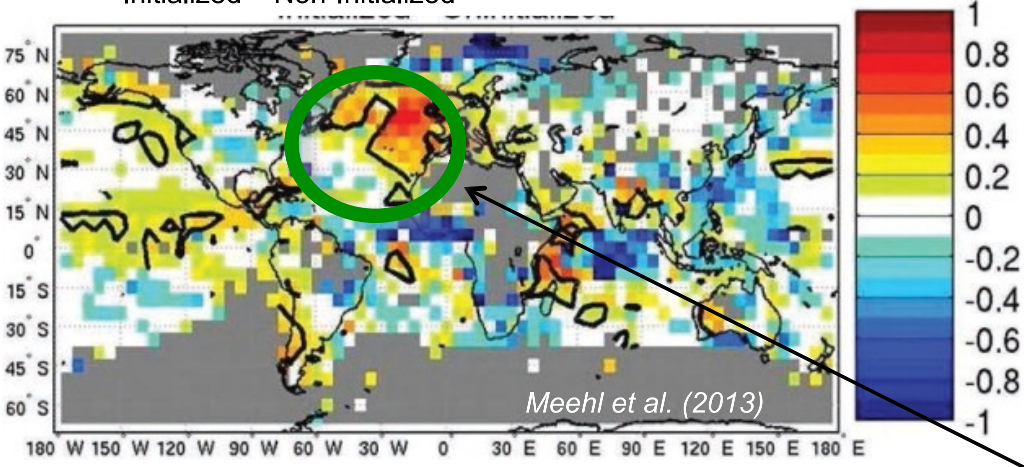
As many values as hindcasts for both the model and the observations to compute skill scores. Ex : correlations



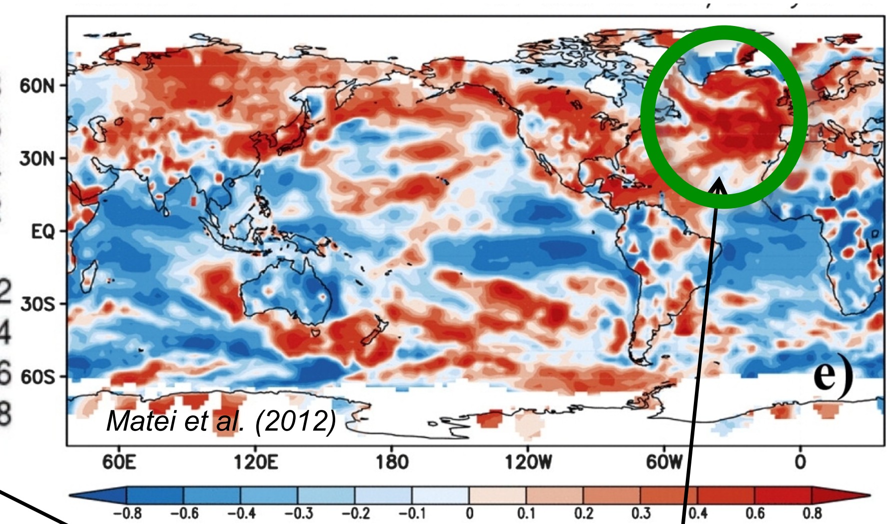
Climate factors influencing Atlantic hurricane activity

Climate factor	Description	Timescale
North Atlantic Sea Surface Temperature		Annual, Decadal, +
El Niño Southern Oscillation	Oscillation in Tropical Pacific Ocean Temp.	Annual (~3-5 yr cycle)
West African Monsoon	Rainfall over Sahel region	Annual
North Atlantic Oscillation (NAO)	Seesaw pattern in sea level pressures b/w Iceland and the Azores	Annual
Solar activity		11-year cycle
Ozone concentration in upper atmosphere		Annual
Dust/aerosols over the Atlantic	Dust originating from Sahara desert	Annual
Madden-Julian Oscillation	Eastward propagating disturbances in the tropics	Intra-seasonal

MME temperature MSSS: year 2-9
Initialized – Non-Initialized

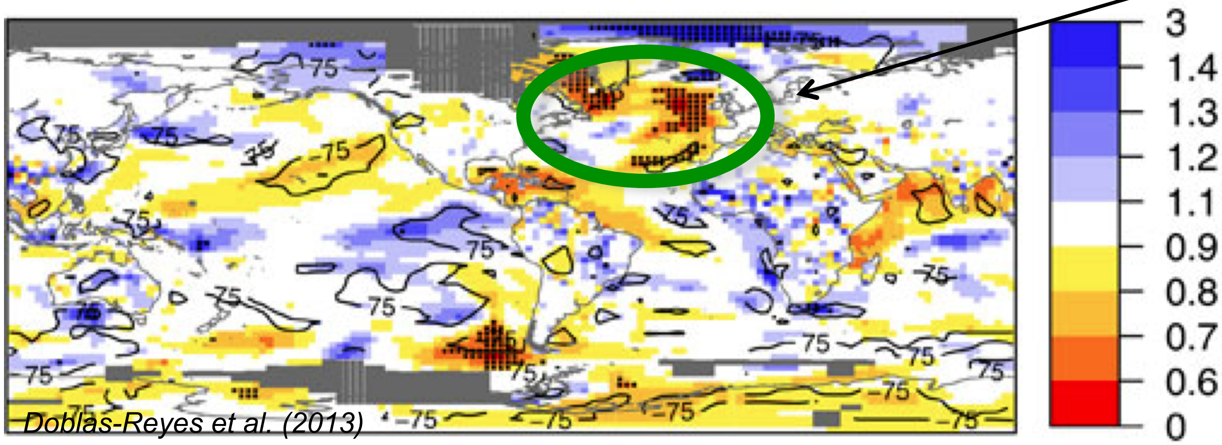


Difference ACC (Initialized – Non Initialized, yr 2-5)

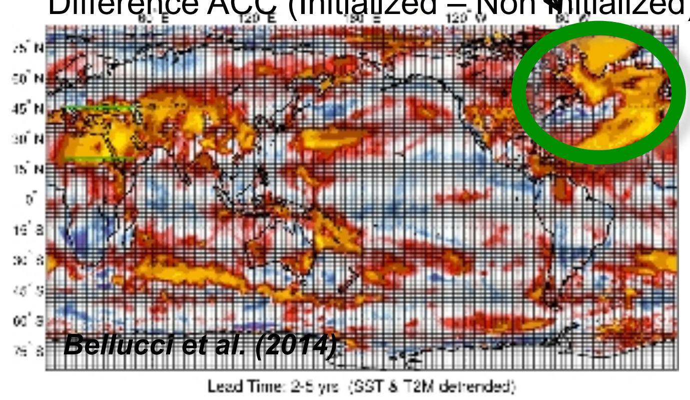


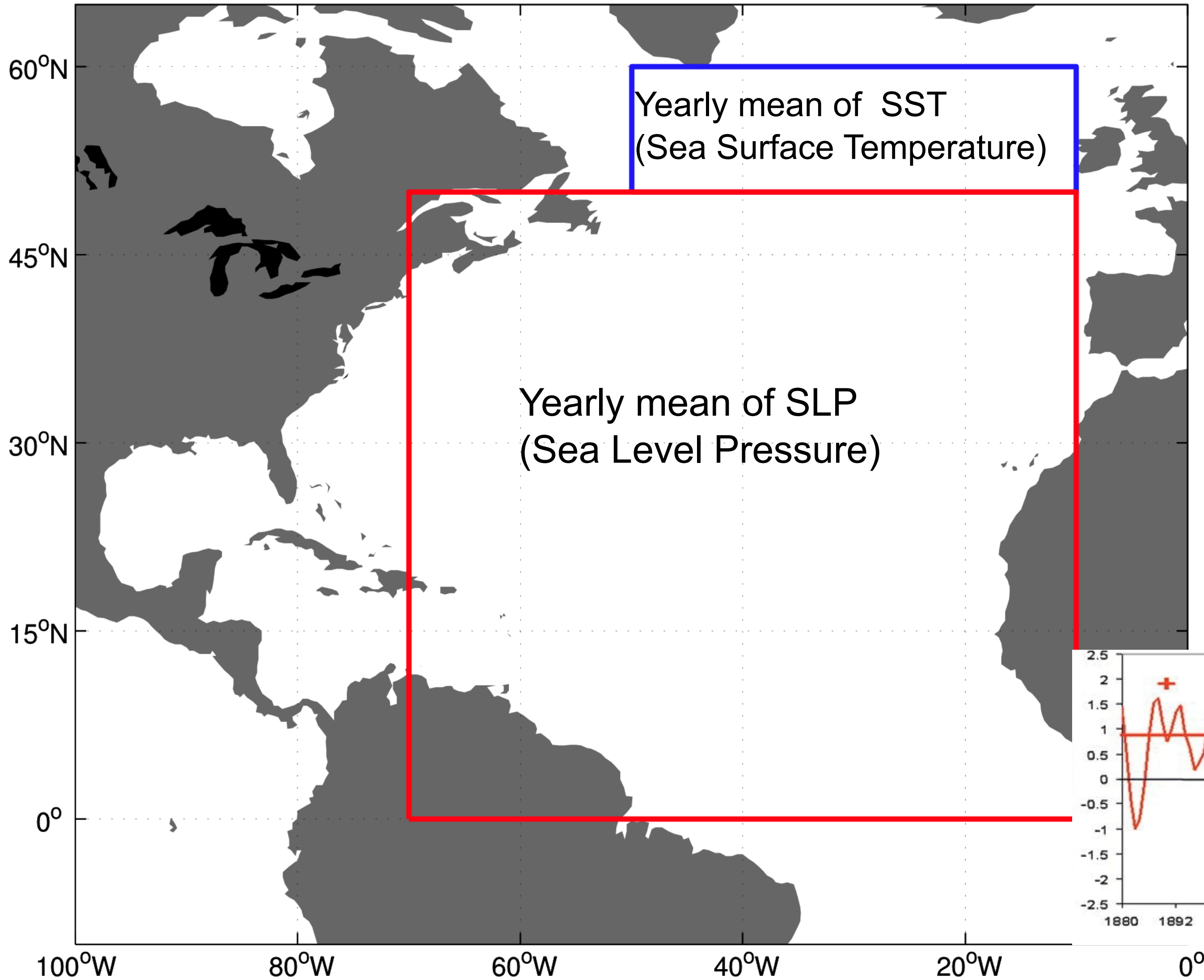
Ratio of the root mean square error (RMSE) of the initialised and uninitialised predictions for the near-surface temperature from the multi-model CMIP5 experiment (1960-2005) for forecast years 2-5.

Added-value from initialisation



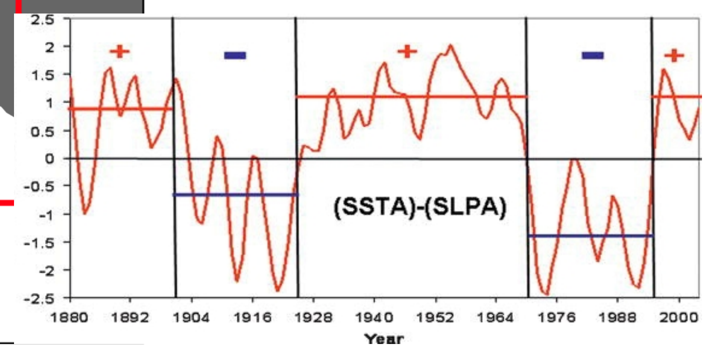
Difference ACC (Initialized – Non Initialized)



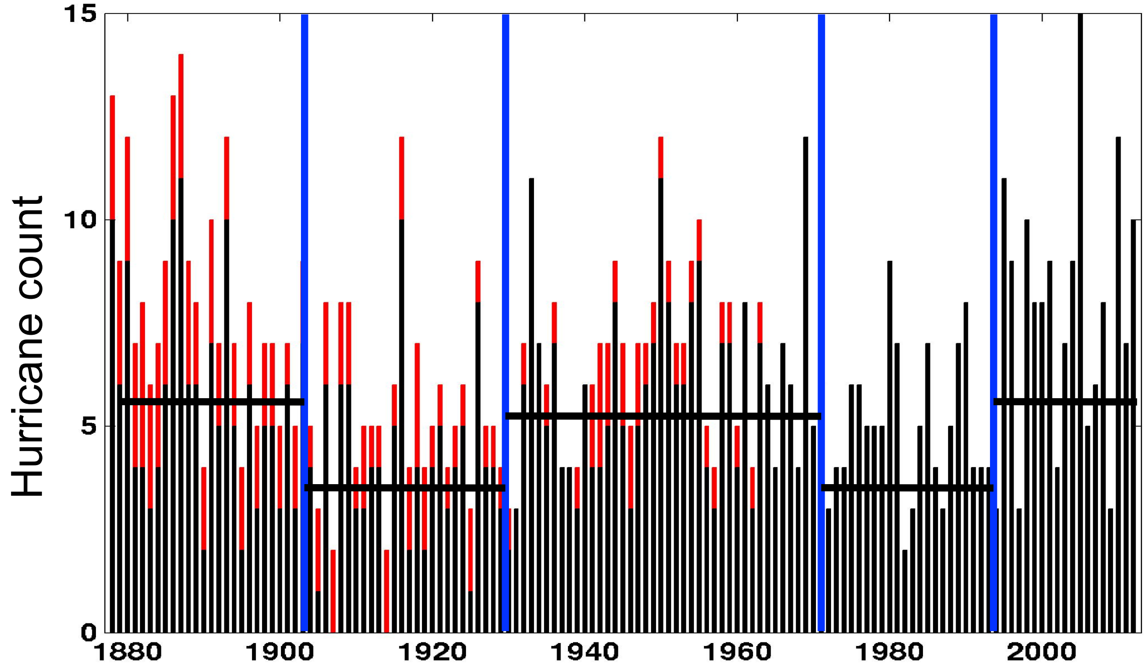


From CSU
Seasonal forecasts:

Index =
Standardized SSTA
–
Standardized SLPA

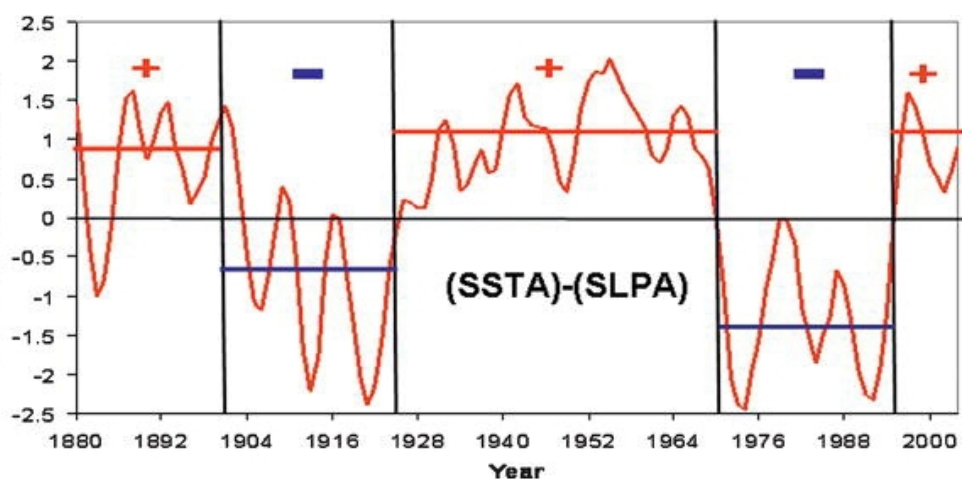


from Klotzbach and Gray (2008)



HURDAT2

Correction by Vecchi and Knutson (2011)



from Klotzbach and Gray (2008)

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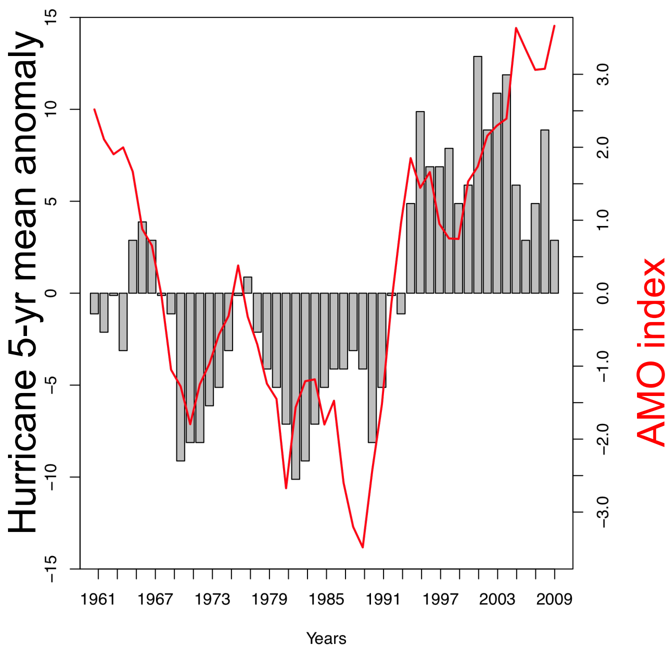
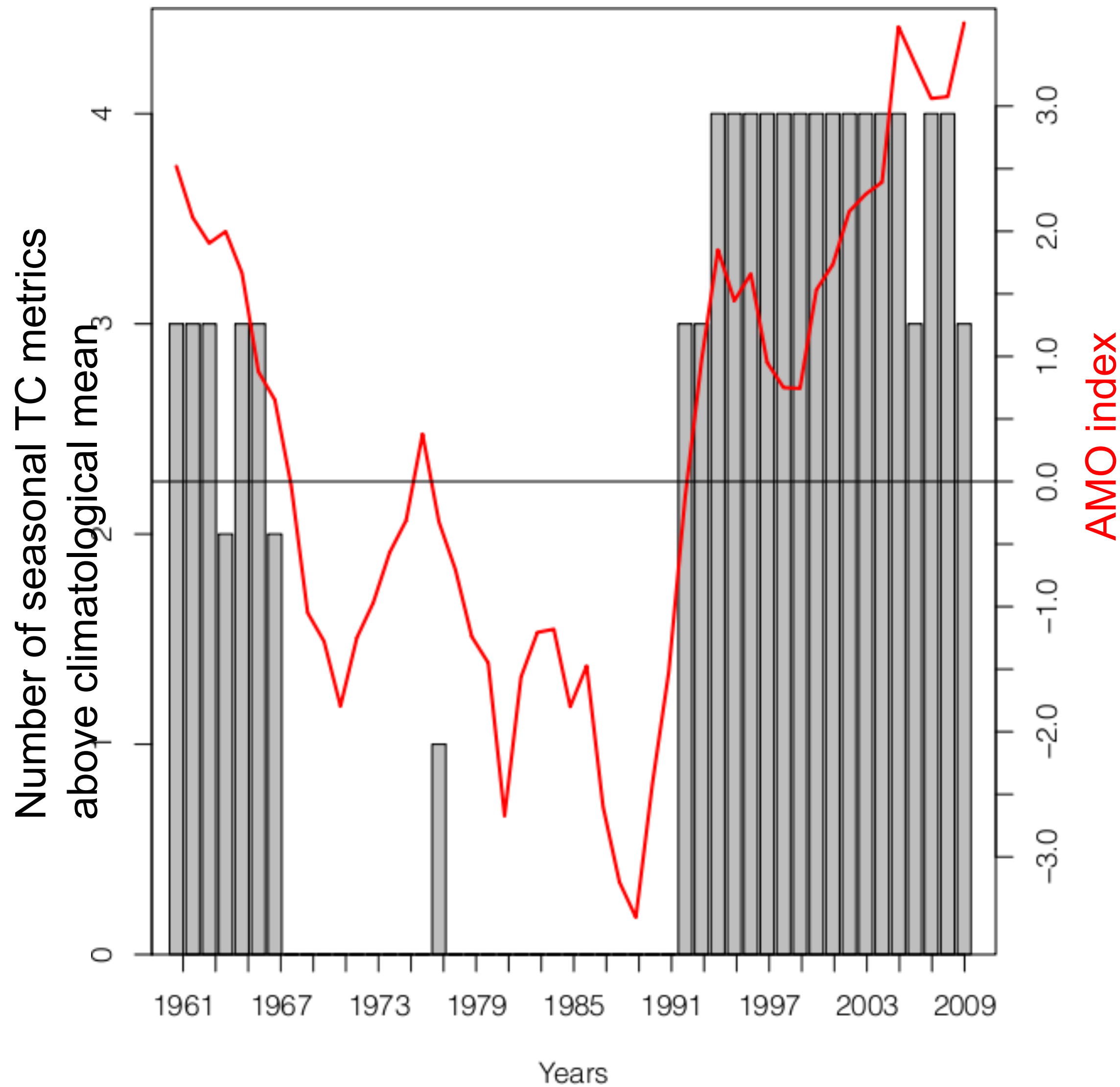


TC metrics are:

- **Number of hurricanes**
- **Number of major hurricanes**
- **Number of hurricane days**
- **Number of major hurricane days**

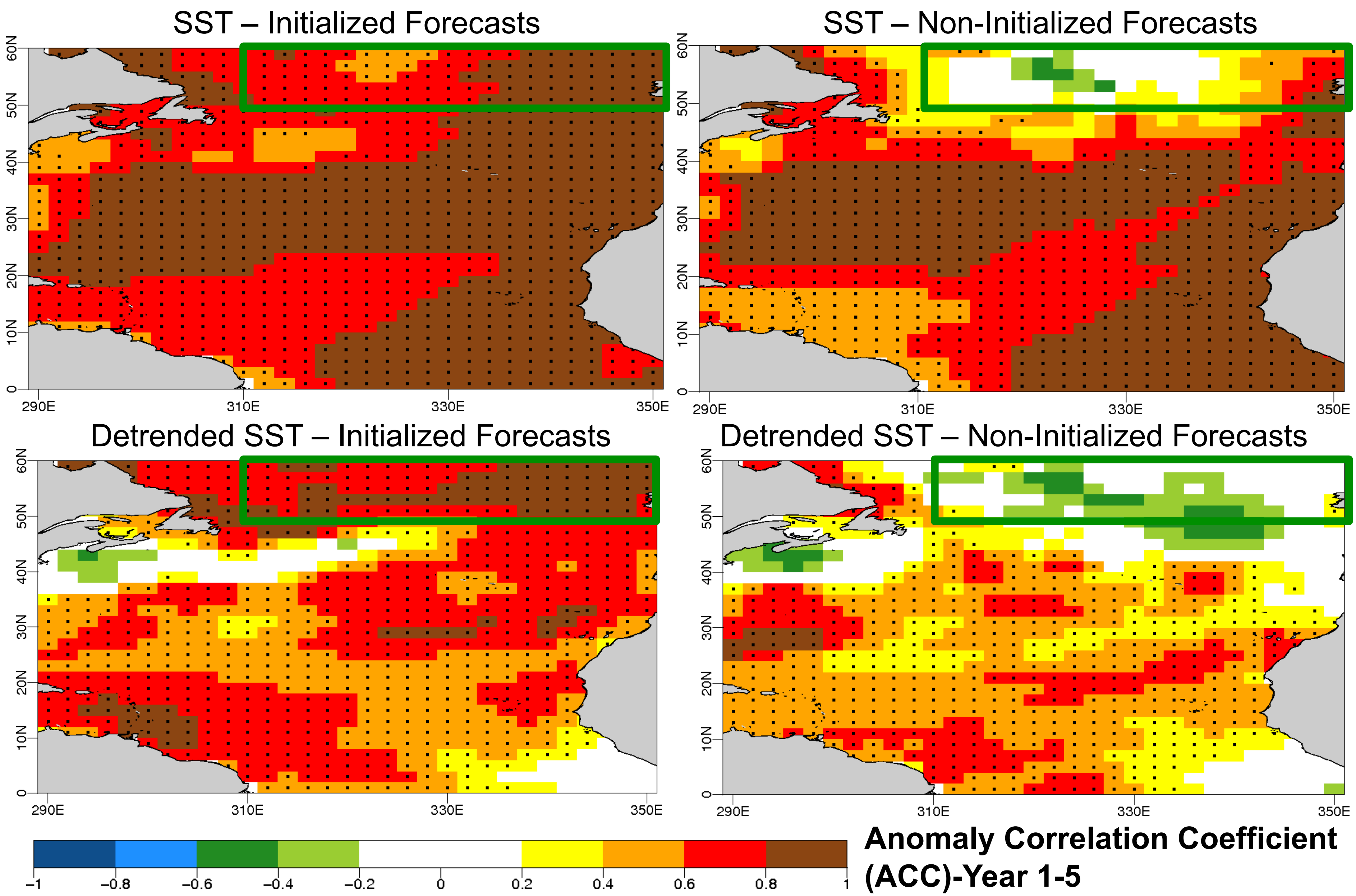


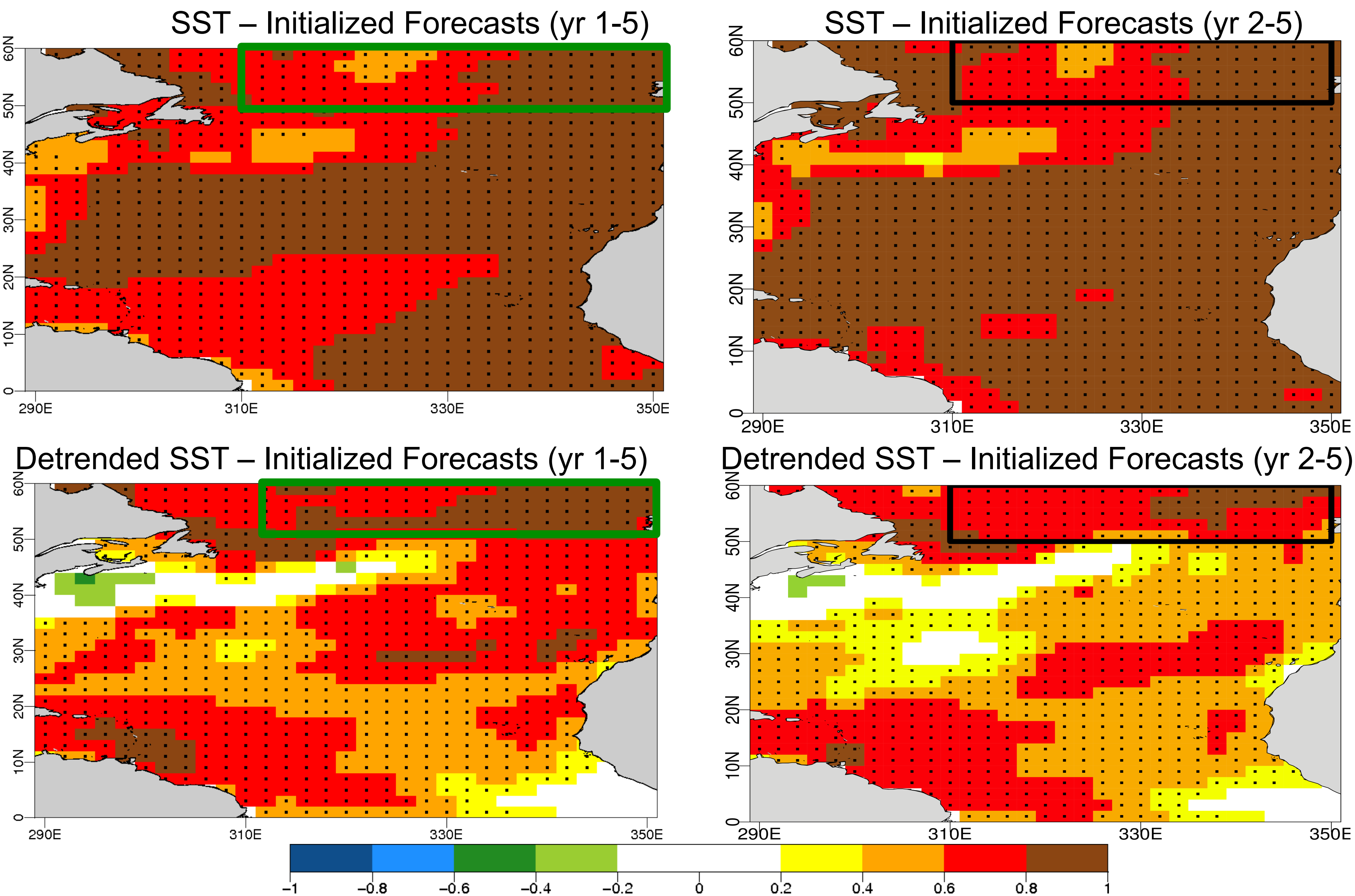
GCMs	Initialized	Non-Initialized
GFDL CM2.1	10	10
HadCM3	10	10
MIROC5	6	3
MPI-ESM-LR	5	3

CMIP5
SPECS (Seasonal-to-decadal climate Prediction for the improvement of European Climate Services)

Start dates: yearly, 1961 to 2010
5-year mean predictions (1961-1966 to 2010-2014)

Model selected based on
1) skill over designated area,
2) start dates available every year


SST – Initialized Forecasts
SST – Non-Initialized Forecasts
Detrended SST – Initialized Forecasts
Detrended SST – Non-Initialized Forecasts
0
10N
20N
30N
40N
50N
60N
290E
310E
330E
350E
–1
–0.8
–0.6
–0.4
–0.2
0
0.2
0.4
0.6
0.8
1
Anomaly Correlation Coefficient (ACC)-Year 1-5


SST – Initialized Forecasts (yr 1-5)
SST – Initialized Forecasts (yr 2-5)
Detrended SST – Initialized Forecasts (yr 1-5)
Detrended SST – Initialized Forecasts (yr 2-5)
0
10N
20N
30N
40N
50N
60N
290E
310E
330E
350E
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1

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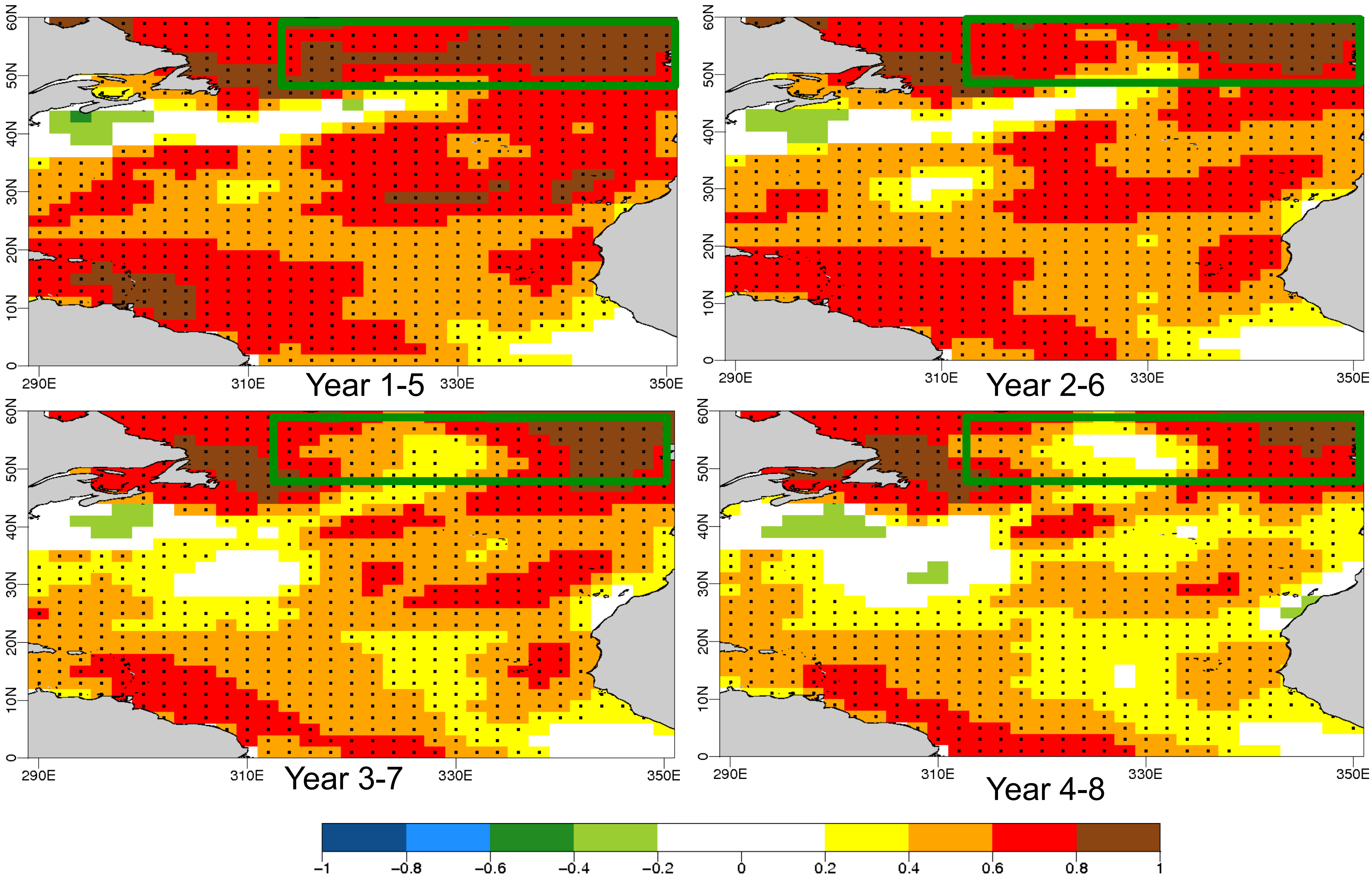
ACC, 5-year mean MME detrended SST – Initialized Forecasts



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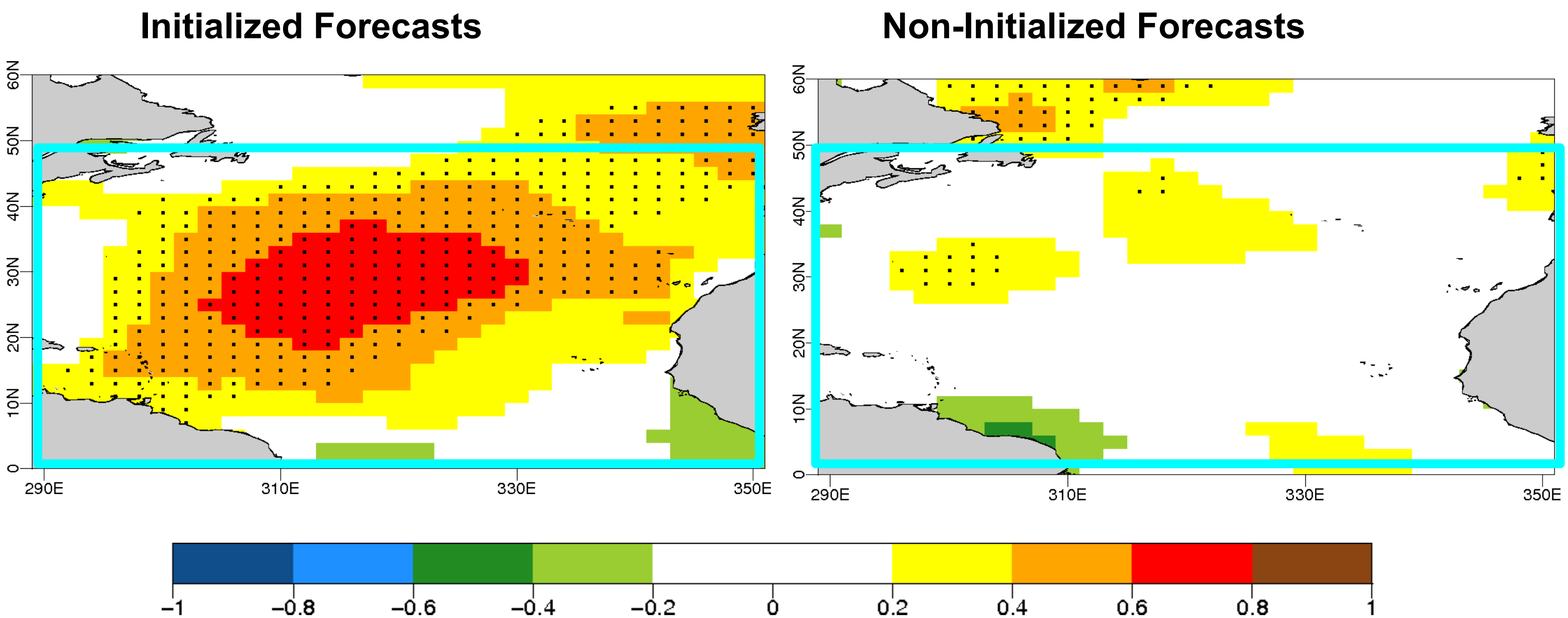
ACC MME – MSLP (year 1-5)



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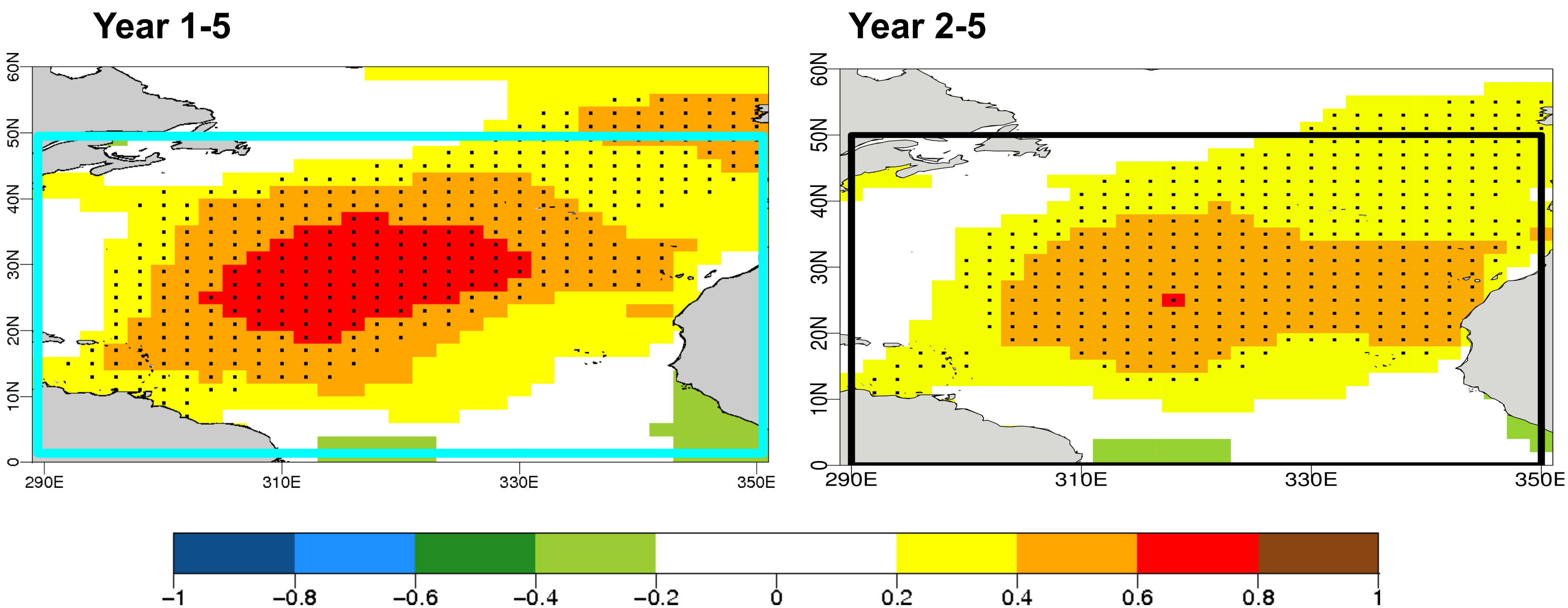
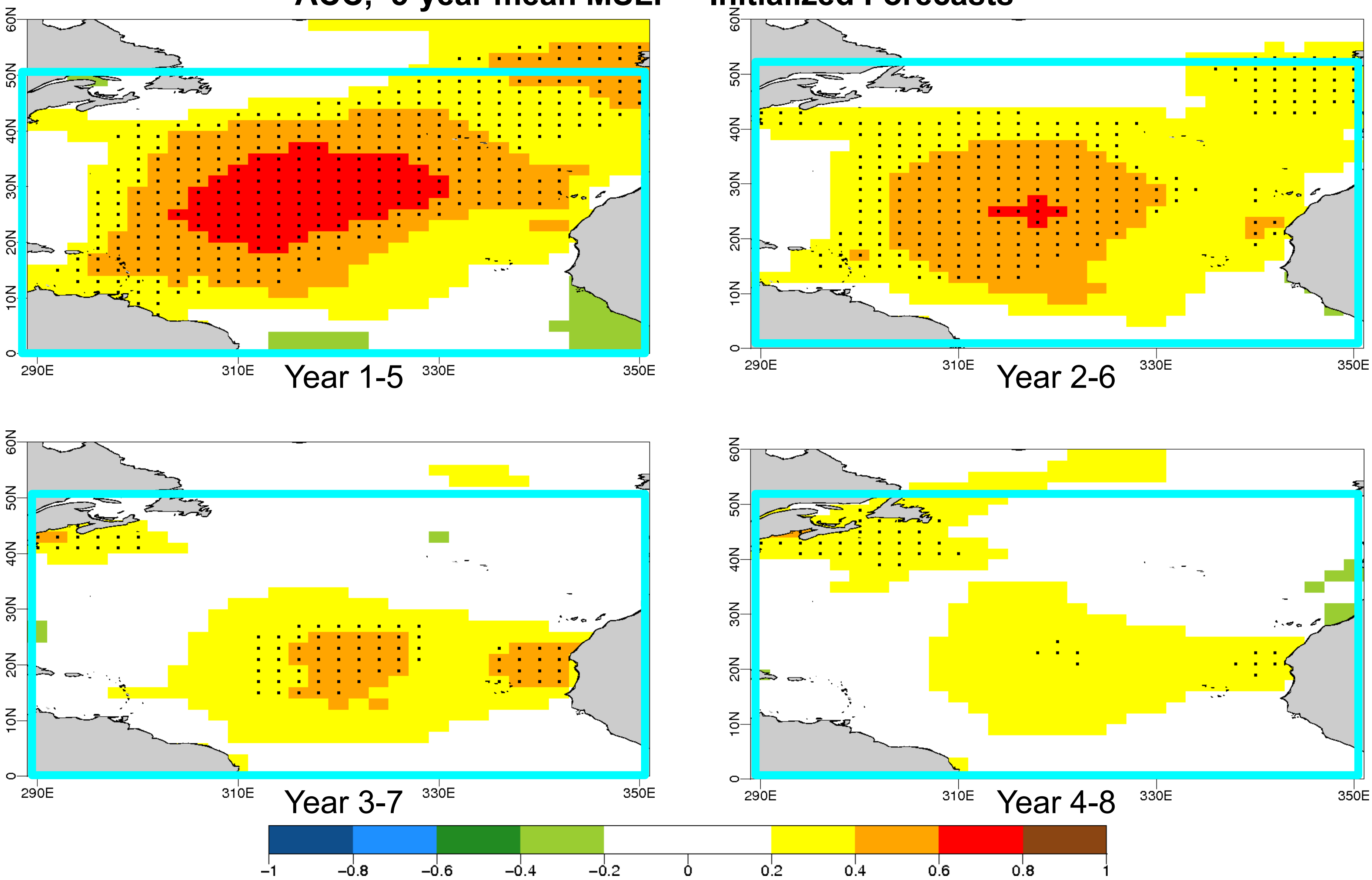
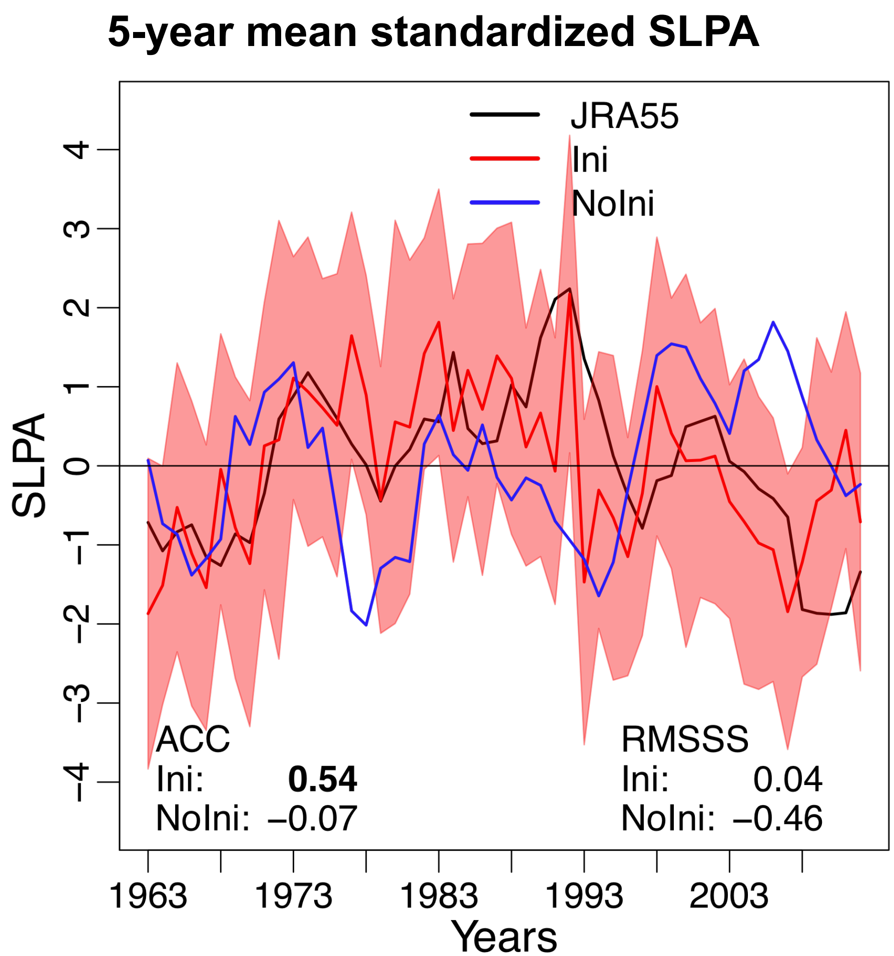
ACC - MME

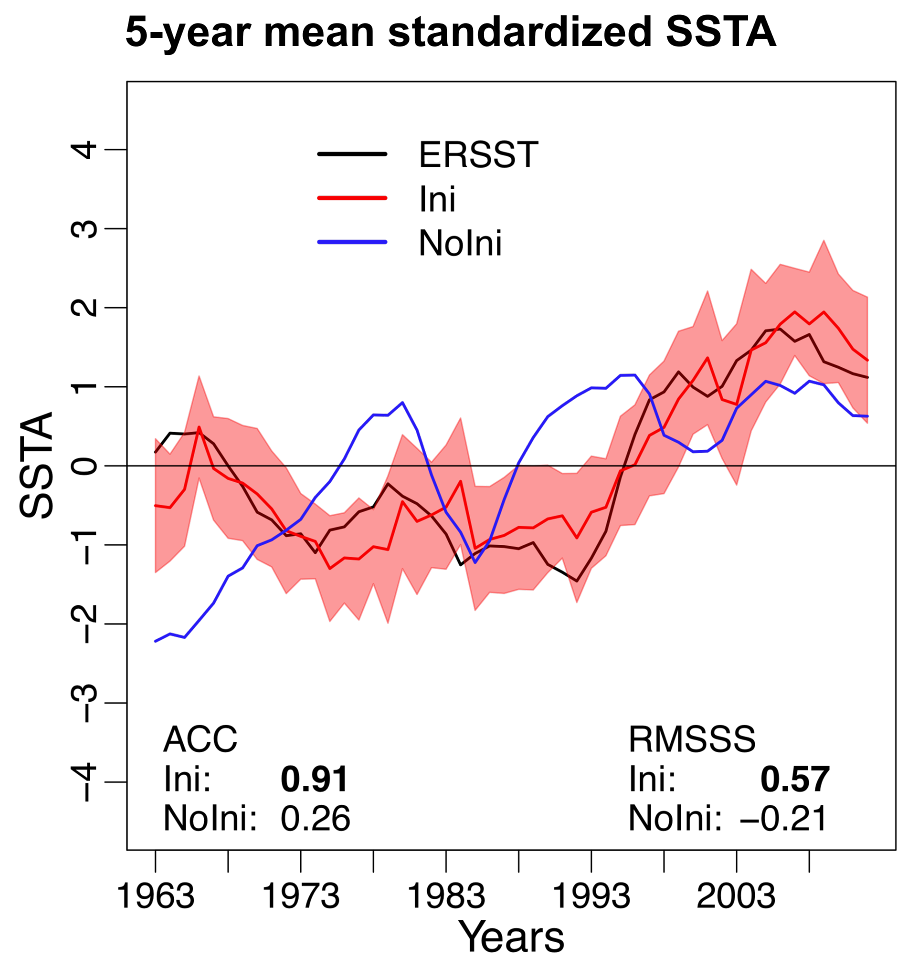
MSLP –Initialized Forecasts



ACC, 5-year mean MSLP – Initialized Forecasts





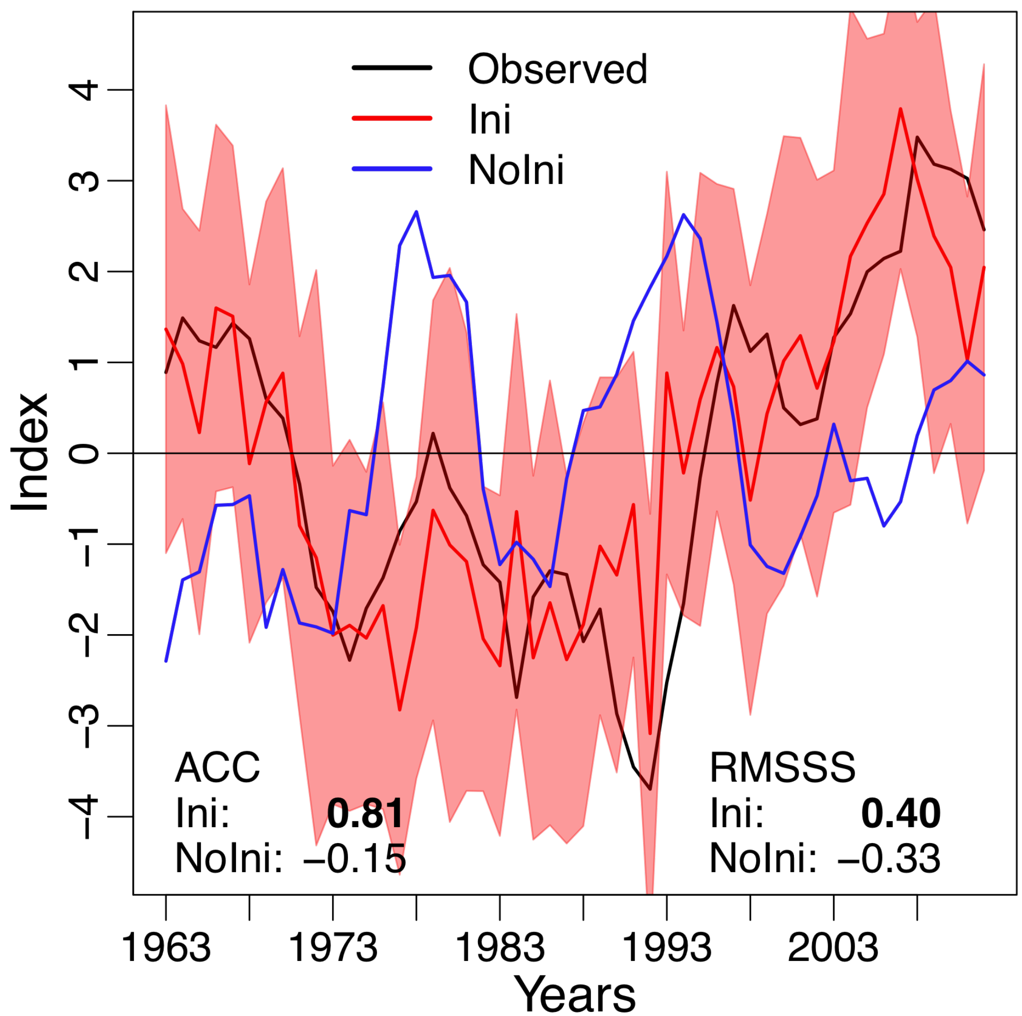


$RMSSS = 1 - RMSE / RMSE_{clim}$

1: perfect prediction

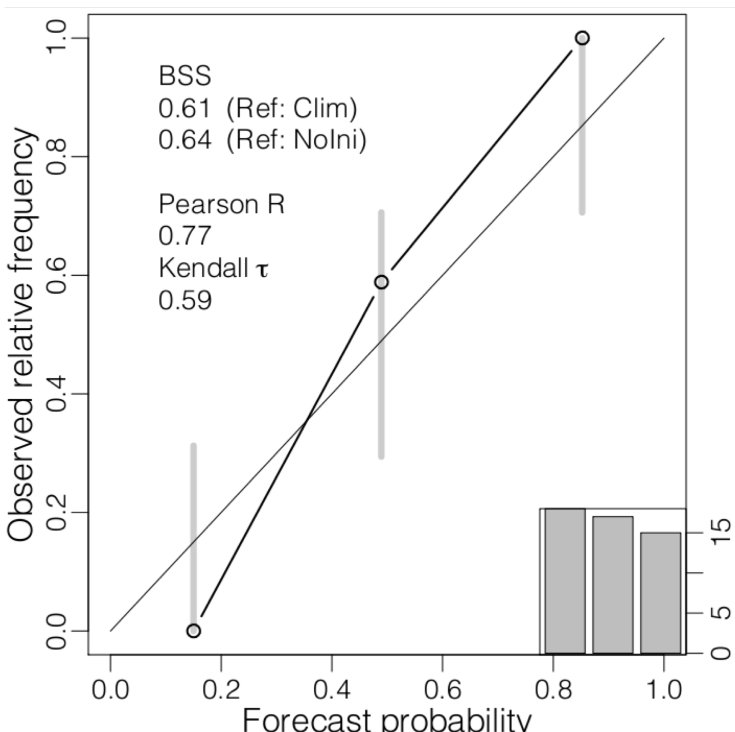
0: no improvement over climatological forecast

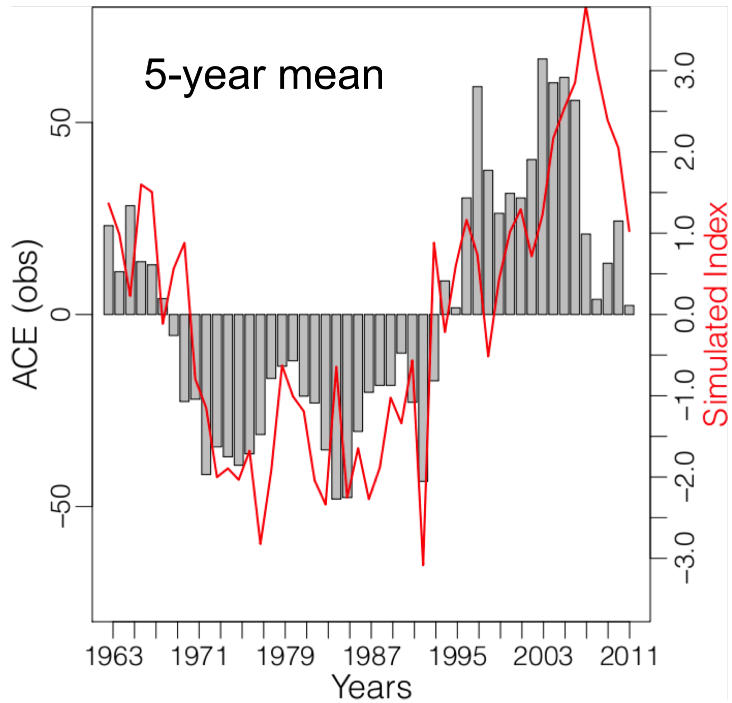
5-year mean index



How does this skill translate into forecasting cyclone activity?

Probability to have + ACE anomaly

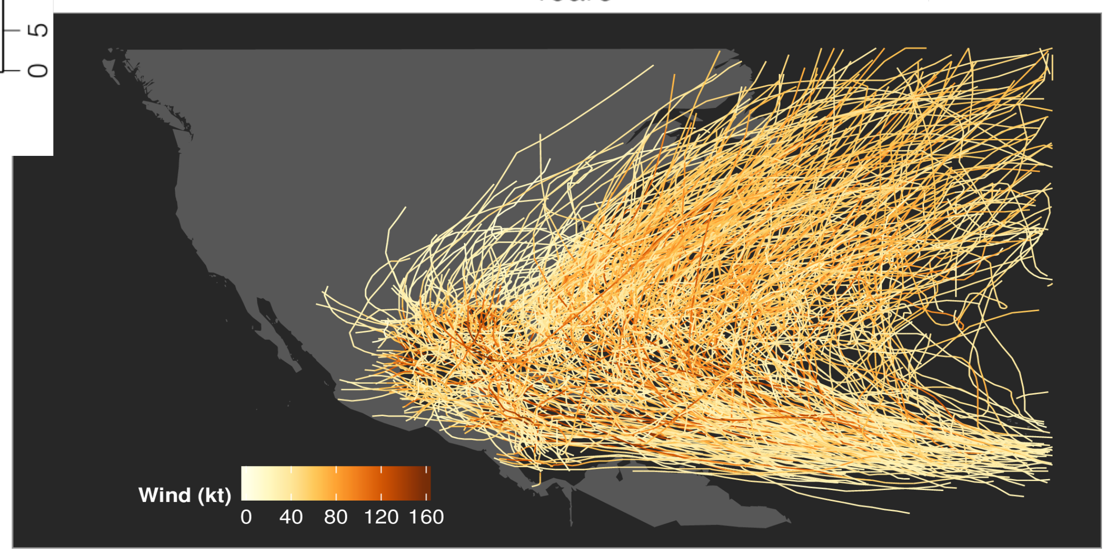




$BSS = 1 - BS / BS_{ref}$

1: perfect prediction

0: no improvement over climatological forecast



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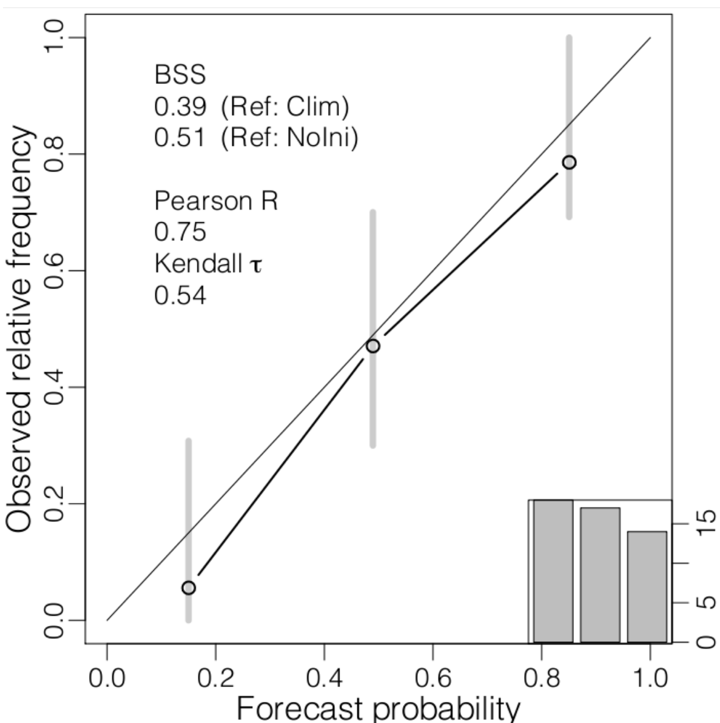
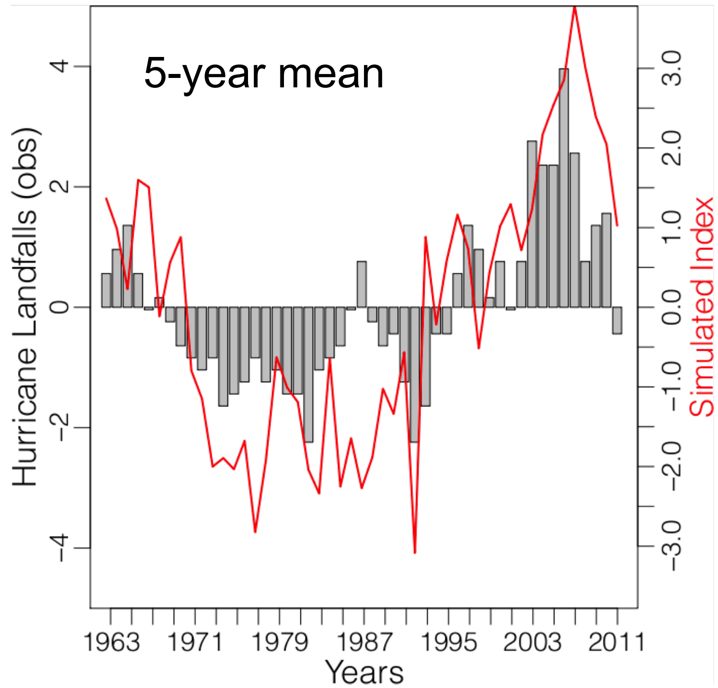
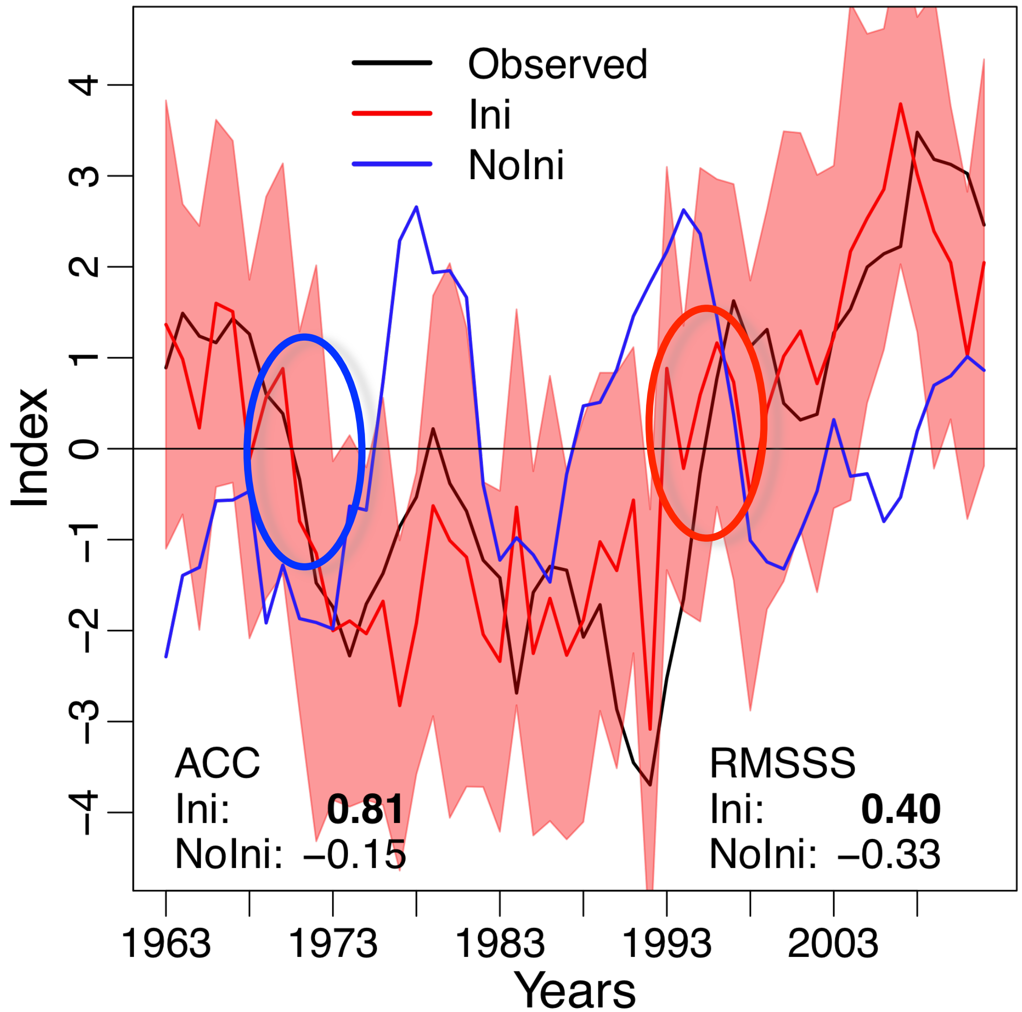
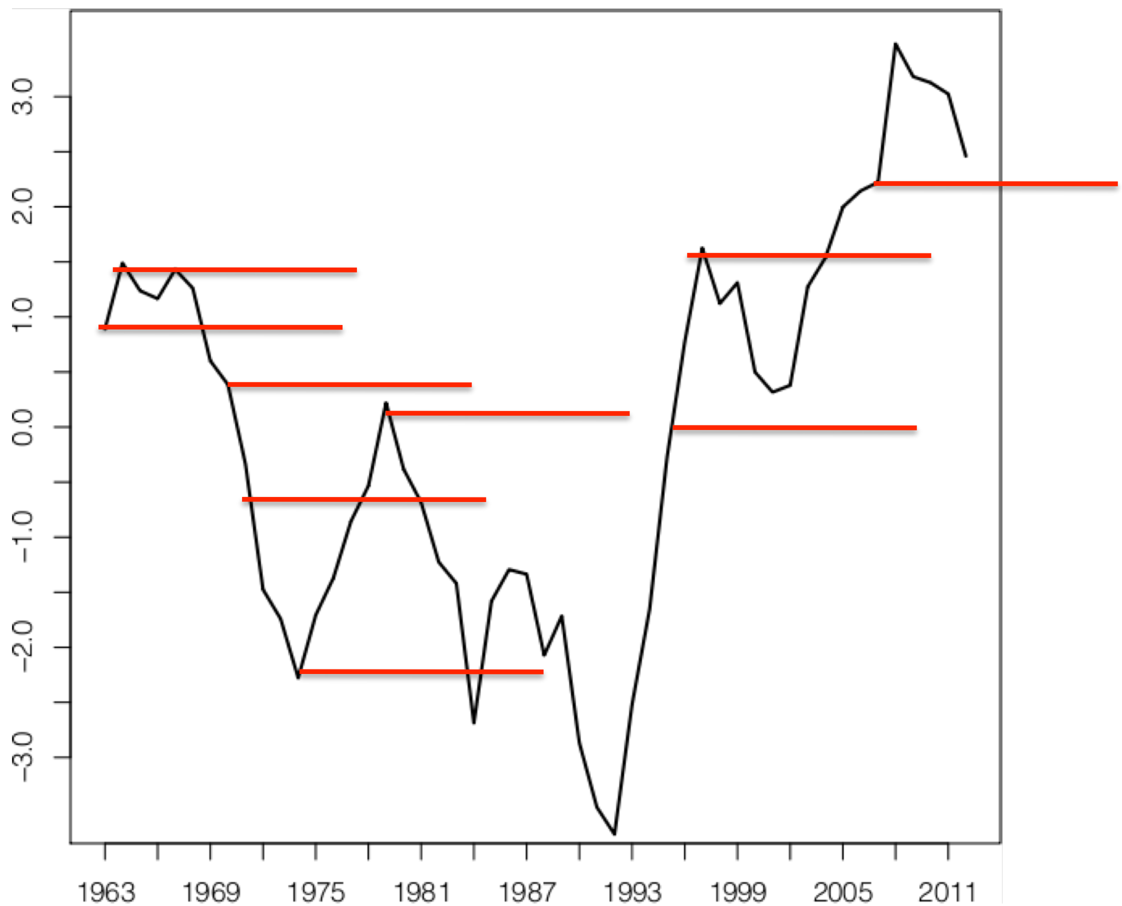
Probability to have + hurricane landfall anomaly

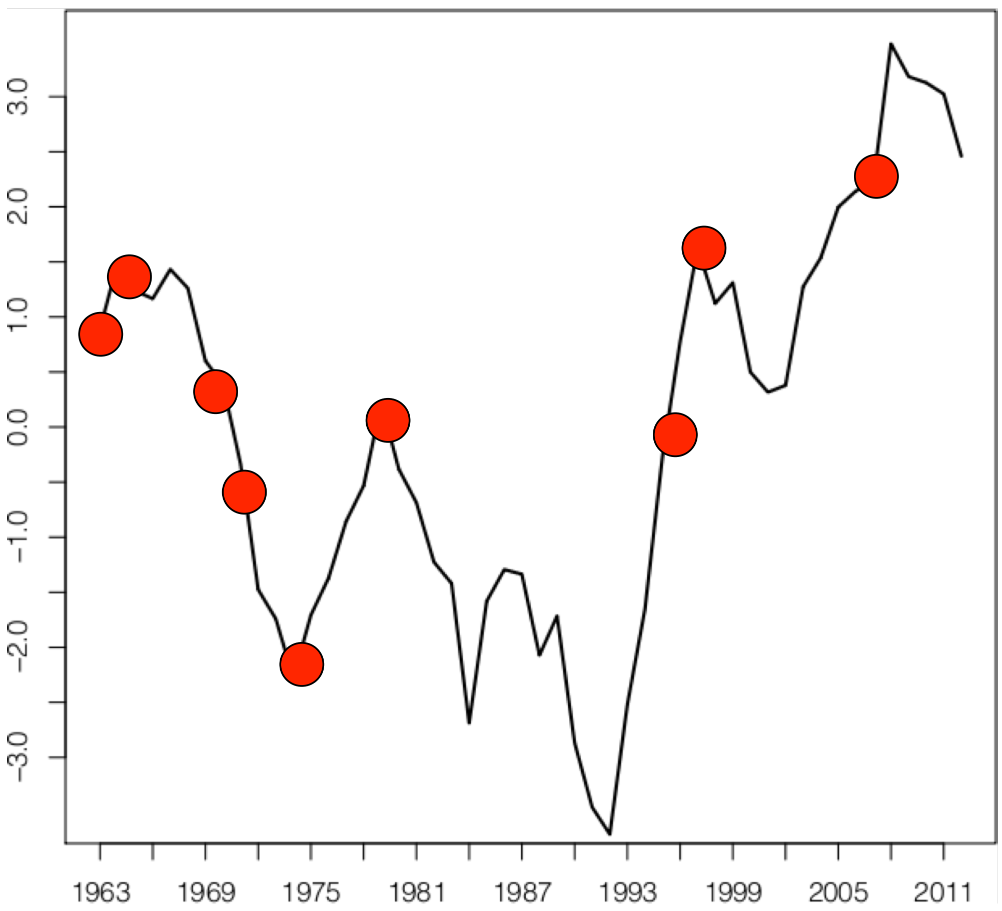




Can we predict the shift between active and inactive phases?




3.0
2.0
1.0
0.0
−1.0
−2.0
−3.0
1963
1969
1975
1981
1987
1993
1999
2005
2011



Still good correlation, but no predictive power

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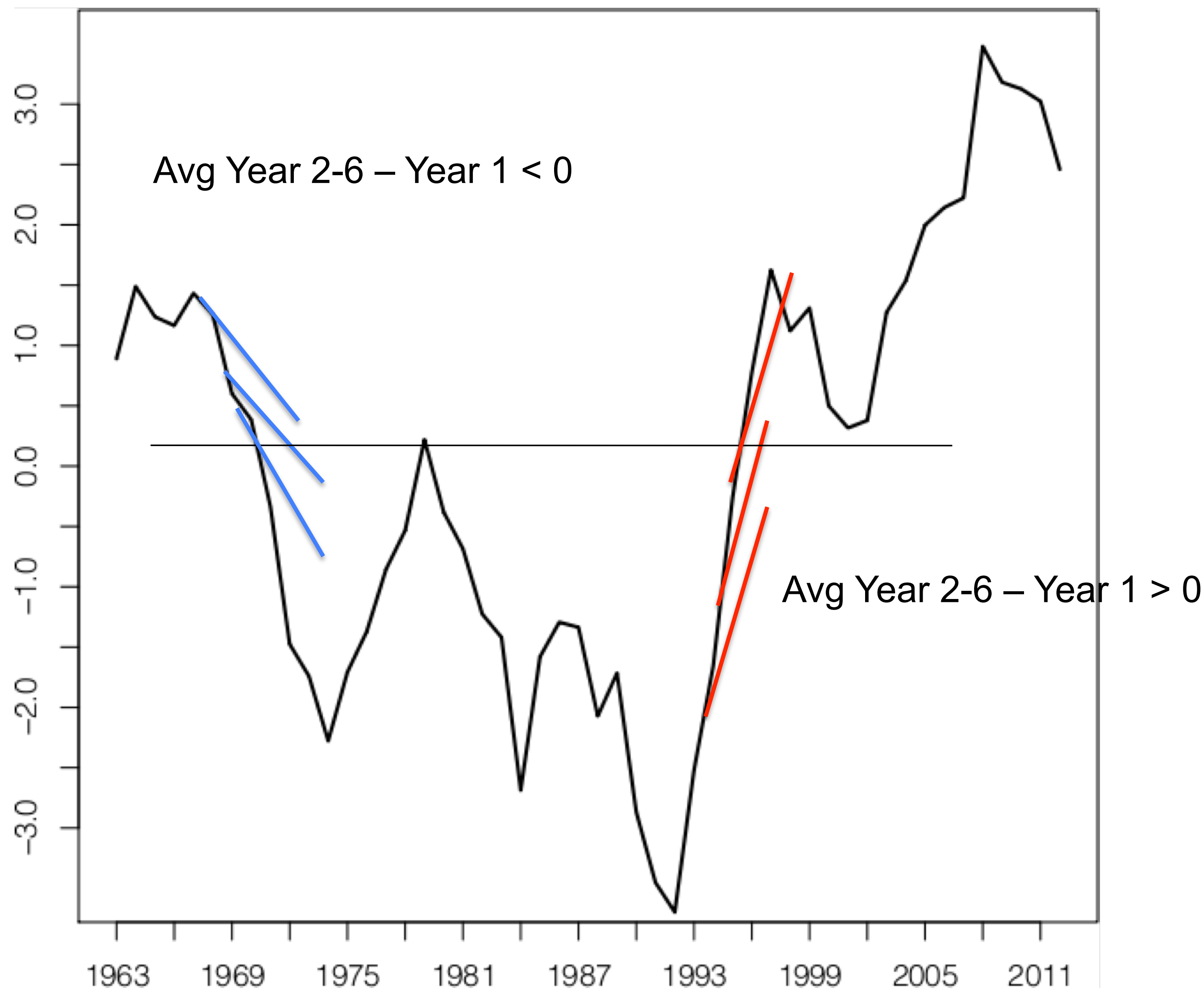
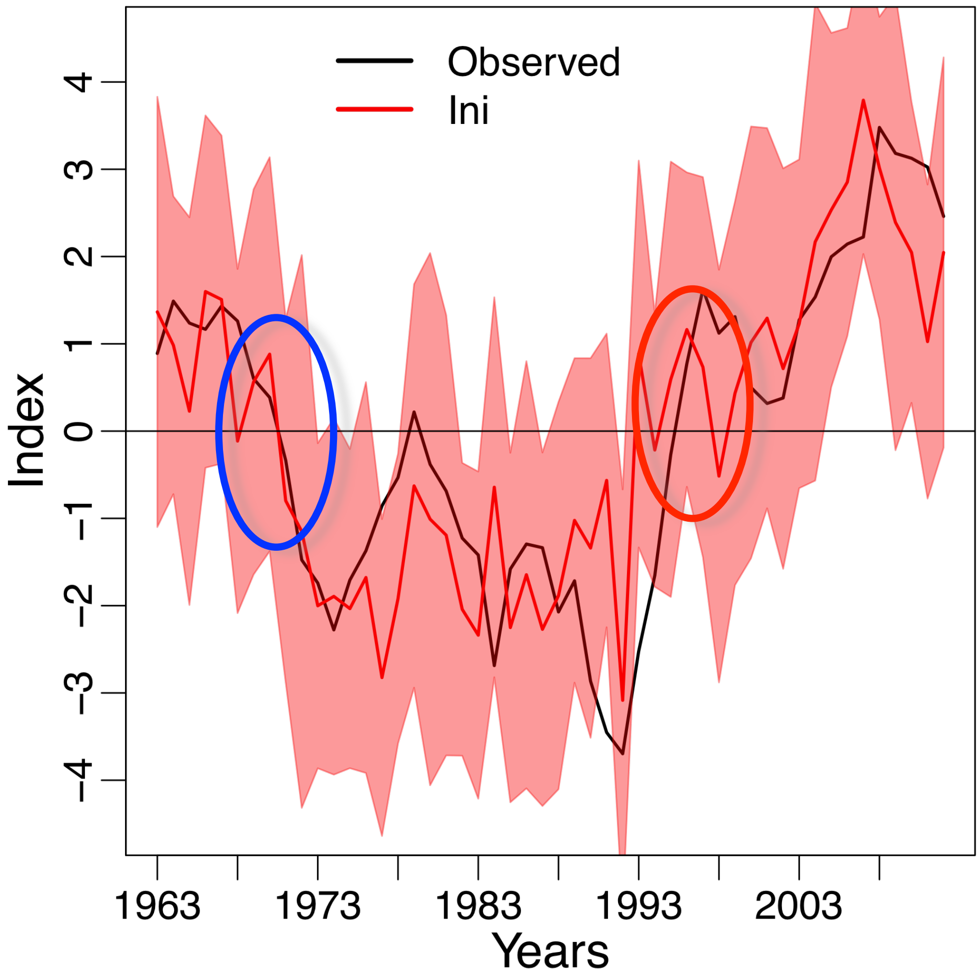
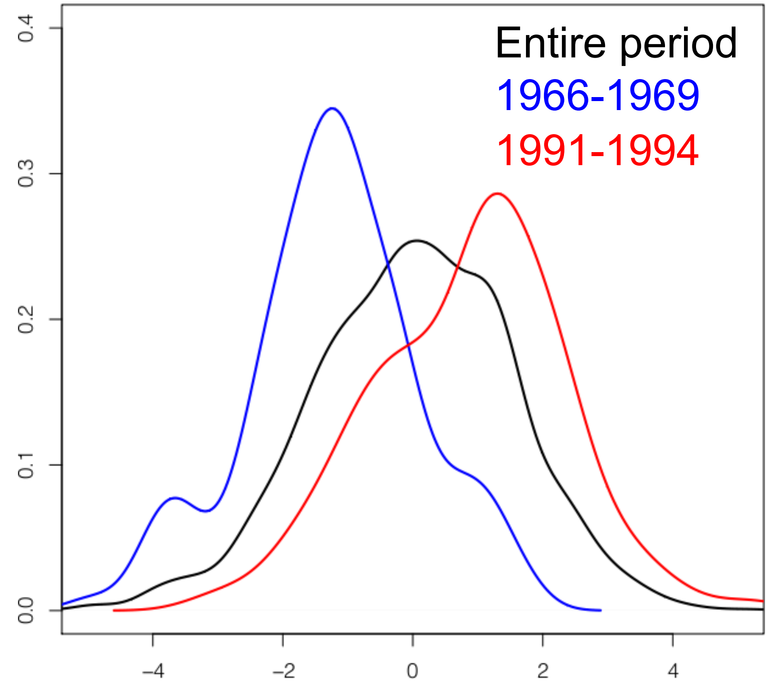




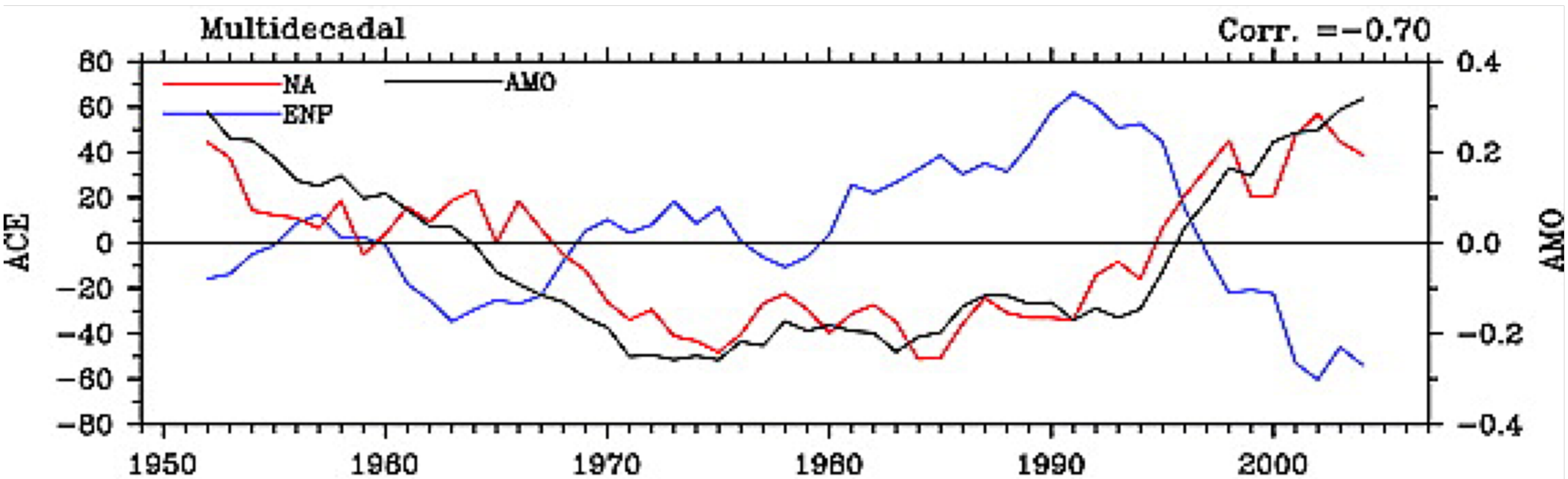
PDF Distribution
Avg Year 2-6 – Year 1



Could the technique be applied in other other basins?

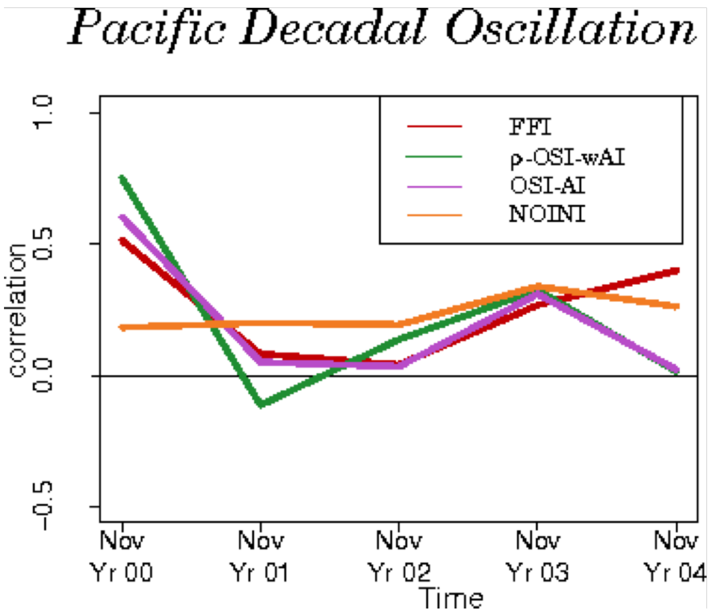
Prospect in eastern Pacific

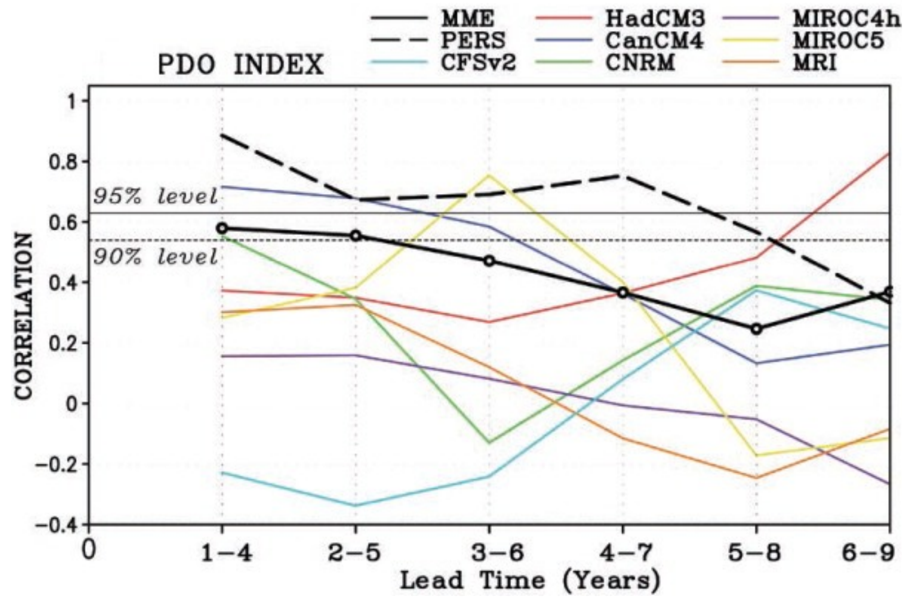
Low frequency anti-correlation with Atlantic



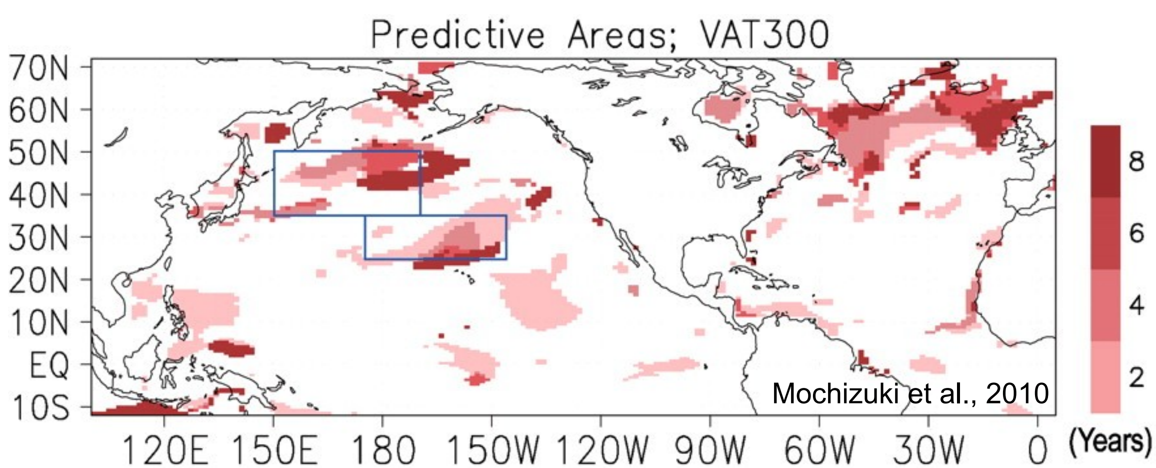
Wang et al., 2012

Western North Pacific?





Meehl et al., 2013



Mochizuki et al., 2010

More of a challenge…

Summary

- Initialized GCMs do seem capable of predicting CSU index, which is linked to Atlantic TC activity, at multi-annual timescale (5yrs)
- Skill doesn't come only from persistence, i.e. we have some skill at predicting shift between active and quiet phases
- Perspective: plan to extend period of study using decadal forecasts spanning the entire 20th century

***NATURE* | LETTER**

Ocean impact on decadal Atlantic climate variability revealed by sea-level observations

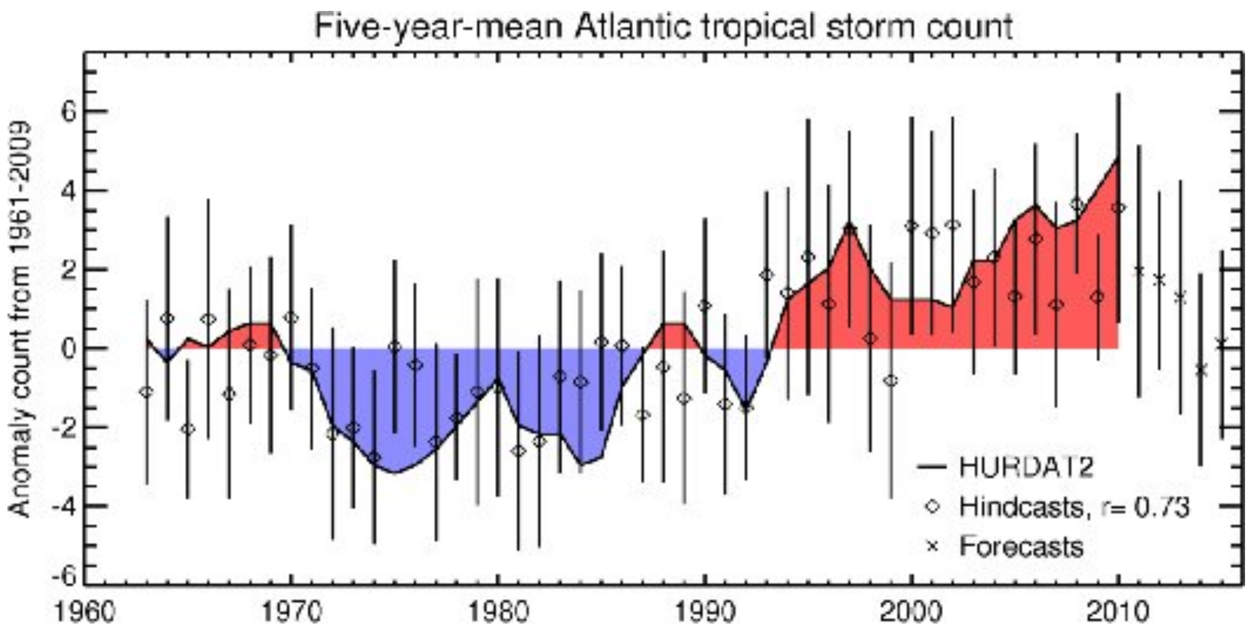
Print

Gerard D. McCarthy, Ivan D. Haigh, Joël J.-M. Hirschi, Jeremy P. Grist & David A. Smeed

Nature **521**, 508–510 (28 May 2015) doi:10.1038/nature14491
Received 03 July 2014 Accepted 08 April 2015 Published online 27 May 2015

Decadal variability is a notable feature of the Atlantic Ocean and the climate of the regions it influences. Prominently, this is manifested in the Atlantic Multidecadal Oscillation (AMO) in sea surface temperatures. Positive (negative) phases of the AMO coincide with warmer (colder) North Atlantic sea surface temperatures. The AMO is linked with decadal climate fluctuations, such as Indian and Sahel rainfall[1], European summer precipitation[2], Atlantic hurricanes[3] and variations in global temperatures[4]. It is widely believed that ocean circulation drives the phase changes of the AMO by controlling ocean heat content[5]. However, there are no direct observations of ocean circulation of sufficient length to support this, leading to questions about whether the AMO is controlled from another source[6]. Here we provide observational evidence of the widely hypothesized link between ocean circulation and the AMO. We take a new approach, using sea level along the east coast of the United States to estimate ocean circulation on decadal timescales. We show that ocean circulation responds to the first mode of Atlantic atmospheric forcing, the North Atlantic Oscillation, through circulation changes between the subtropical and subpolar gyres—the intergyre region[7]. These circulation changes affect the decadal evolution of North Atlantic heat content and, consequently, the phases of the AMO. The Atlantic overturning circulation is declining[8] and the AMO is moving to a negative phase. This may offer a brief respite from the persistent rise of global temperatures[4], but in the coupled system we describe, there are compensating effects. In this case, the negative AMO is associated with a continued acceleration of sea-level rise along the northeast coast of the United States[9, 10].

Subject terms: Physical oceanography Climate-change impacts Climate sciences



Hermanson et al., 2014

More info:
Caron, L.-P., L. Hermanson, and F. J. Doblas-Reyes (2015) Multiannual forecasts of Atlantic U.S. tropical cyclone wind damage potential, Geophys. Res. Lett.,42, 2417–2425.

Thank you

Image credit: NASA